SCIENTIFIC REPORTS

OF THE

Imperial Agricultural Research Institute, New Delhi

(Including the Report of the Sugarcane Expert, Coimbatore)

For the year ending June 30, 1936

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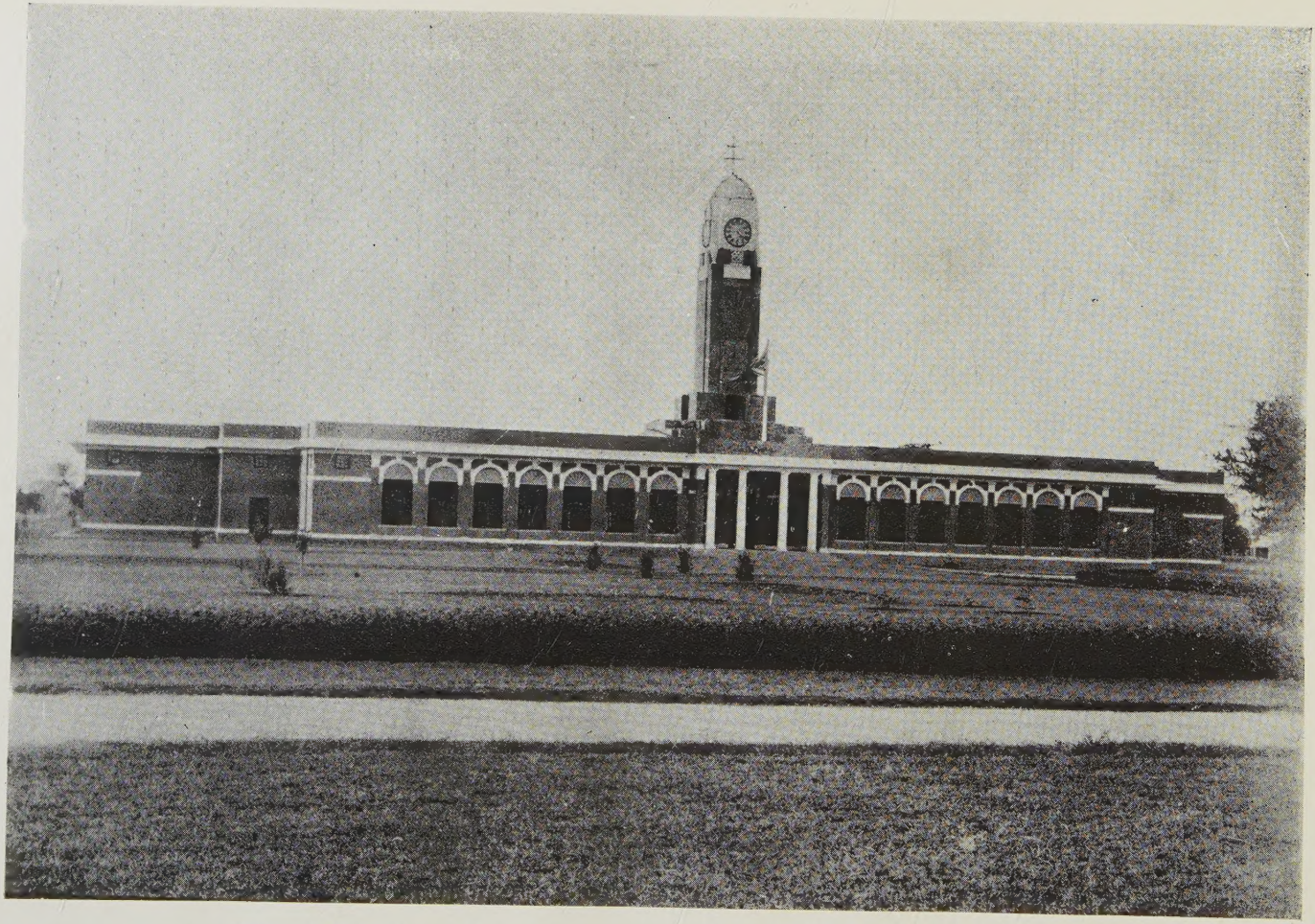

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PLATE I.

SCIENTIFIC REPORTS

OF THE

Imperial Agricultural Research Institute, New Delhi

REPORT OF THE DIRECTOR

1935-36

(Rao Bahadur B. Viswa Nath, F. I. C.)

I. THE TRANSFER OF THE INSTITUTE TO NEW DELHI

The biggest and the most important event of the year for the Institute is its transfer from Pusa to New Delhi. In the report for the previous year, it was mentioned that, as a consequence of the Phipps Laboratory having been damaged by the earthquake of January 1934, the decision to move the Institute from Pusa to New Delhi was finally taken, and that the necessary preparations were in progress. During the year under review, these preparations were completed and the actual move commenced a month before the year under report came to a close. At the time of writing this report, the move is complete. Instances of wholesale transfer of big Institutes, like the Imperial Agricultural Research Institute at Pusa, are very rare in the annals of research institutions not only in India but elsewhere in the world. A brief description of the move may, therefore, be of interest.

1. The Move

In effecting the transfer, the authorities of the Institute had to face peculiar and unavoidable difficulties which were both physical and financial. The Institute has a population of 1,300 composed of the staff and their families. As it was necessary to pack and despatch things till the last item had left Pusa and to receive at the Delhi end the packages of the different Sections of the Institute as they arrived, the staff had to remain on duty at Pusa and move to Delhi with the least possible delay. This necessitated the maintenance of sanitary and health services, of the hospital and of the

power house at Pusa till the last moment, and the running of a parallel set of services at Delhi for the advance party. The large dairy herd of the famous pedigree Sahiwal cattle must be fed while they stayed at Pusa, *en-route* between Pusa Road and Delhi, and immediately on arrival. It was, therefore, necessary to continue to grow fodder at Pusa and to maintain the Veterinary Dispensary and a host of cattle attendants till the middle of October. At the same time, the raising of fodder crops was taken up at Delhi as soon as it was possible, so that the herd on arrival would have enough fresh fodder and silage. The facilities at the Agricultural Sub-station at Karnal were pressed into service to raise the necessary food-stuffs for feeding the cattle at Delhi, as the land at Delhi would not be ready to grow sufficient food grains and *bhusa* for the cattle there. This necessitated considerable expansion of the cultivated area at Karnal immediately on taking over from the Imperial Dairy Expert under whose charge the Karnal Farm was till January 1936. There were a number of post-graduate workers under training distributed in the different Sections. It was important that the move should be so effected as to cause the minimum amount of hiatus to their work. The laboratories had to be kept open and field operations had to continue till the end of harvest in the month of May 1936. The crop-breeding work of the Botanical Section could not be allowed to suffer, as there has always been a pressing demand for improved seed of different crops which the Section has been handling. All this necessitated the maintenance of office work in the Central and Sectional Offices, which we could not afford to dislocate even for a day although it was being carried on under the great disability that the staff of the Director's Office had been distributed between Delhi and Pusa. On the financial side the cost of the move had to be restricted to the savings effected in the normal budget of the Institute, and to this end stringent restrictions had to be placed on expenditure and posts that had fallen vacant for longer or shorter periods could not be filled. This naturally had its repercussions on the effective strength of the Institute. To circumvent the financial stress and strain occasioned by the move, all available area at Pusa was placed under commercial cultivation of sugarcane. It was anticipated that a sum of Rs. 50,000 to Rs. 60,000 would be realised by the sale of the crop, but as ill luck would have it, although weather conditions were propitious in the beginning, the crop suffered from heavy rains and waterlogging for over a month by floods. This was followed by insect damage, and the result was that the receipts actually realised by the sale of the sugarcane crop amounted to Rs. 37,600. It is pleasing to be able to state that all the physical and financial difficulties have been overcome, and the move has been successfully completed without any embarrassment, financial or otherwise. This result is attributable mainly to the cheerful co-operation and hard work by every

member of the staff in every grade of service. Every item of equipment that was considered useful at Delhi, including heavy office furniture, has been brought to Delhi, and nothing which would be useful now or in the near future has been left at Pusa. The whole of the move worked to schedule.

Earlier in the year all fresh field experimental work was suspended. The several Sections were engaged in sorting out the stores and the equipment, preparatory to final packing. The actual packing which was entrusted to a contractor commenced early in February. As soon as the construction of the buildings at Delhi was substantially advanced to permit occupation, though with temporary inconveniences, orders were issued to suspend all work at Pusa and to concentrate on the move. All Sections were instructed to stop work and commence dismantling and packing from the 1st of May. Water and gas supplies to the laboratories were stopped from that date, and students were allowed to go on their summer recess in the months of May, June and July with instructions to join at Delhi in the first fortnight of August 1936. A move Office was formed with the Joint Director (Mr. Wynne Sayer) as the Move Officer who was responsible to effect the move from Pusa. Likewise, a Receiving Office was formed at New Delhi with the Assistant Economic Botanist (Mr. Kashi Ram) in charge who was responsible for the reception of goods at Delhi. The Move Office and the Receiving Office were allotted members drawn from the staffs of the different Sections to look after the despatch of goods at Pusa and their reception at Delhi. The Move Office was responsible for the arrangements for packing and transport of goods from Pusa to Pusa Road, for the supply of wagons, for loading wagons and to do everything connected with the move. The loading of goods first into carts and later into the wagons was done under the personal supervision of the staff from respective Sections specially deputed for the Move Office ; at the Delhi end a few members of the different Sections, who were transferred in advance to Delhi, received goods for their respective laboratories on notification by the Receiving Officer. The transport of goods from Pusa to Pusa Road railway station was done mainly in bullock carts from the Agricultural Section. At Delhi, the transport of goods from the Delhi-Sarai-Rohilla Station to the Institute was done in motor lorries by a contractor. This arduous task was rendered all the more difficult by the early break of rains in North-East India and the usually heavy rains accompanied by floods, both in Bihar and Delhi, which distinguished the monsoon of 1936.

To avoid transhipment from the metre gauge to the broad gauge and the consequent damage to delicate apparatus, it was decided to carry goods on the metre gauge direct to the Delhi-Sarai-Rohilla Station. Two railway companies were concerned with the railway transport, namely, the Bengal and North-Western Railway and

the Bombay, Baroda and Central India Railway. The complicated business of making declarations for the classification of goods, and the delays that must be occasioned by discussions between the railway staff and the Institute staff in regard to rates, were avoided by arranging a flat rate with the two companies.

As soon as the wagons left Pusa Road Station, the Move Office at Pusa informed the Receiving Office at Delhi, by next post, of the number of wagons, the numbers marked on them, along with the keys of the wagons and copies of lists of contents of boxes, signed by the respective Heads of Sections who superintended the packing, and countersigned by the Joint Director who directed the move. Goods liable to octroi duty at Delhi were marked with a distinctive red mark; this and the list of contents enabled the packages to pass the Octroi Barrier at Delhi without delay. A Breakdown-Fieldman was stationed at the Pusa Road Station. His duties were to proceed immediately, on telegraphic information, from any of the stations *en-route*, of accidents like hot axle, breakage of locks, load shifting, etc., to the station concerned, break seals, check contents, unload the wagon and reload another. Although doubts were at first expressed as to the necessity for such a step, it was ultimately found that this was a wise move, as, on four occasions, this Breakdown-Fieldman had to run up to different stations *en-route* and see to the transhipment of goods without loss or damage. All items requiring heavy cranes were grouped together in one consignment to avoid heavy haulage charges if sent in several lots.

As soon as every arrangement was found satisfactory, orders were issued on the 26th of May, 1936, to start the move on the 1st of June, 1936. The despatch of all dead-stock was completed by the 15th September 1936. Apart from live-stock which were accommodated in 32 wagons, about 100,000 cubic feet space was requisitioned from railways for carrying the Institute equipment. The employment of expert packers reduced the bulk which many delicate apparatus would have assumed in inexperienced hands; the arrangements with railways for move wagons to travel without break of gauge permitted thousands of articles to be sent unpacked; the number of wagons and open trucks used was thus materially reduced without leaving anything behind that should be brought. The Joint Director personally supervised the move of the cattle, their food and attendants in a special train consisting of 43 wagons. The train was timed to leave Pusa Road at 18-20 on the evening of the 15th October and arrive at Delhi-Sarai-Rohilla Station at 10 A.M. on the 19th October. The cattle, which were all previously protected by the serum simultaneous inoculation against rinderpest, were accompanied by the Cattle Superintendent, a Camp Veterinary Dispensary and all arrangements were made for the milking of the cattle *en-route* four times a day. From the accounts point of view, the disposal of milk on the journey between Pusa Road and Delhi was a problem. It was not possible to

arrange for sale *en-route* either by contract or otherwise. In the former case there was no certainty that we would be able to keep the contract, and in the latter case delay would be the result. This difficulty was got over by re-investing the milk.

Thus ends the move of the Imperial Institute of Agricultural Research at Pusa, which was inaugurated 30 years ago and became well known in India and abroad as the 'Pusa Institute', and which holds a proud and enduring record of achievements in the science and practice of agriculture.

2. The New Site of the Institute

On its transfer from Pusa to New Delhi, the Institute is renamed as the 'Imperial Agricultural Research Institute, New Delhi'.

In its new environments, the Institute has one great advantage, namely, the easy accessibility from all parts of India, the lack of which was recognised as a great disability of Pusa. This comparative inaccessibility of Pusa and the consequent separation of its scientific workers from those in the Provincial Institutes and in the Universities, did not allow that scientific contact outside the Institute which is so essential for the efficient life of a Research Institute. The Institute at Delhi enjoys a spacious and central environment enabling it to cover a wider field of activity and fruitful co-ordination. The workers at the Institute can meet and exchange ideas with the workers from the Provincial Agricultural Institutes and the Universities coming to attend the meetings of the Imperial Council of Agricultural Research. This contributes directly to increasing the usefulness of the Institute and its work by creating the cultural contacts which are so necessary for the proper functioning of the Institute.

Soon after the final decision to move the Institute was taken, progress with the New Institute has been very rapid. By February 1935, the necessary approach roads were made. His Excellency Lord Willingdon, the Viceroy and Governor General of India, laid the foundation stone of the Library, which is the chief central building of the Institute, on the 19th February 1935. A block of residences for accommodating the small staff of the advance lay-out party were made ready immediately, and the lay-out party in charge of the Assistant Economic Botanist (Mr. Kashi Ram) took charge of the preliminary side of the agricultural work in the month of May 1935.

3. Lay-out

The total area of the Institute consists of about 800 acres, of which about 275 acres are under buildings and pasture and the rest is agricultural land which has been laid out into fields for experiment and research. The work entrusted to the lay-out party consisted of fencing the estate boundaries, levelling the fields,

making field roads, construction of water-courses, falls, culverts and sluice gates, laying pipes for unfiltered water supply and other miscellaneous work which is directly of agricultural interest. The whole of the estate with the exception of the southern boundary towards the ridge was fenced with Ideal fencing covering a total length of 30,175 running feet. Trees in the midst of fields and deep-rooted weeds and grasses from fields were removed. The flow of storm water through the steep ridges had not only made innumerable undulations all over the place but, in its flow for years, had deposited a considerable quantity of coarse sand in the beds of *nullahs*. These were cleared and the land intended for agricultural purposes was levelled. For breaking the hard dry soil and for shaping the lands into fields steam tackle and scoops were used, in addition to teams of bullocks and scrapers. The area roughly levelled between August 1935 and August 1936 was over 150 acres. Field roads 15 feet wide were made, their total length being 21,757 feet. For irrigating the fields, water from the Jumna river has been made available by taking off a 24-inch pipe line from the Bholibatyari reservoir. The length of the pipe line laid is 12,100 feet. This line brings water to a point close to the Institute from where open adjunct channels carry the water to the agricultural area. The main water-course which takes off water from the Institute's end of the pipe line was designed to carry 10 cusecs and the subsidiaries 5 cusecs of water. The total length of the former so far made is 5,300 feet and that of the latter is nearly 19,100 feet. The supply to the irrigation channel is taken off from a masonry reservoir built at the tail end of the pipe. For irrigating the roadsides and the residential area and the compounds of residential and non-residential buildings, a 9-inch branch has been taken off the 24-inch main.

4. Buildings

Hand in hand with the progress in the lay-out of the agricultural land, the progress of building construction in the hands of the Central Public Works Department was phenomenally rapid. The Library and the Laboratories were ready by April 1936 to commence the work of internal fittings and equipment.

The Institute at New Delhi differs from that at Pusa both in design and construction. The residential portion embodies the accumulated experience and wisdom of the Central Public Works Department, and provides many modern conveniences and amenities which were not available at Pusa.

The Students' Hostel is complete in its equipment and is designed to accommodate 24 students.

Unlike at Pusa, the Laboratories are single-storeyed buildings and have been built as independent separate blocks for the various Sections instead of housing them all in one building, as was the

The Scoop at Work

Levelling with Scrapers

case at Pusa. Each block contains suites of well-equipped laboratories for advanced research and study.

Library.—The Library is a beautiful and spacious central building designed to accommodate about two lakhs of volumes. It is intended to assist those engaged in advanced study and research by rendering available to them information contained in technical literature. It has, besides the publications by the Institute which are over five hundred, others published in India and abroad. There is an extensive collection of transactions of scientific societies, and of bulletins, monographs and reports issued by Government Departments, Experiment Stations, Scientific Institutions and Research Laboratories dealing with the several sciences directly or indirectly connected with agriculture. There are at present 70,000 volumes and the Library of the Institute is recognised as the largest agricultural library in the East. A classified subject index of books, periodicals and articles is readily available, and, as soon as circumstances permit, endeavours will be made to provide indexed abstracts of articles and to supply photostats of articles to outsiders on payment of the cost of materials. A spacious reading room, in which are exhibited current books and periodicals, is open for consultation from 8 A.M. to 8 P.M.

Agricultural Section.—The block of buildings for the Agricultural Section is situated towards the western boundary of the Institute and consists of two sets: one includes a dairy cattle byre with modern fittings, a veterinary dispensary, exercise grounds for cattle, calf boxes, bull runs, sick animal and segregation sheds. These buildings are entirely devoted to the maintenance and development of the pedigree Sahiwal herd; the other set of buildings consists of bullock byres, godowns, implement sheds and a workshop for carrying out running repairs. The main farm area comprises of 475 acres in a compact block to be devoted to cultivation and field experiments. The soil is suitable for growing almost all the field crops of the plains.

Botanical Section.—This comprises of two adjacent blocks of buildings. The main block for scientific laboratories consists of a number of rooms well fitted and equipped for advanced research. The out-buildings are situated in an area of 50 acres for plant-breeding work. The activities of the Section which have been chiefly confined to plant genetics in the production of new types and varieties of various crops will be continued, and an additional feature at Delhi will be the development of work in Physiological Botany and Cytology.

Chemical Section.—The block of soil science and agricultural chemistry, which for the sake of convenience is called 'Chemical Block', is a spacious building, the rooms of which are divided into a number of individual laboratories for general and analytical

chemistry, micro-chemistry, soil micro-biology, soil physics and physical chemistry, organic chemistry and plant chemistry. An insulated underground room for maintaining even temperature, a cool room, a small laboratory workshop and glass blowing room, a pot-culture house and lysimeters, photographic rooms, dark rooms and direct and alternating currents, which are essential adjuncts for the different laboratories, are also provided. Two new features in this block of buildings consist of the provision of a small laboratory for carrying out small-scale investigations on the utilisation of agricultural wastes and products and to devise ways and means for the production of intermediate products from agricultural produce. The necessity for such a laboratory was recognised as long ago as 1921 by the Board of Agriculture in India. The other additional feature is the provision of a laboratory for nutritional studies relating to the differential composition and nutritive value of the different types of crops and on the effect of soil conditions and treatment on the composition and nutritive value of cultivated crops.

Entomological Section.—The Entomological Block consists of a main laboratory and a parasite laboratory. The main laboratory is designed and equipped for the investigation of every aspect of agricultural entomology. It has separate rooms devoted to the study of different Orders of Insects. No actual census of the collection, which is considered the best collection of agricultural entomology in India, has been attempted, but it is estimated to contain over 10,000 differently named species represented by several hundreds of thousands of specimens, both pinned and in spirit. The parasite laboratory is a new feature of the Institute at Delhi, and is intended to rear and study insects useful in combating the ravages of crop-pests by encouraging the development of those which are parasites on crop-pests but harmless to man, animal or crops. All imported insects under quarantine conditions will be studied under controlled temperature and humidity conditions to ascertain the response of the parasites in climatic variations occurring under natural conditions.

Mycological Section.—The block of buildings for mycological research constitutes a number of well-appointed rooms suitable for investigating the conditions for the development of fungi, bacteria and viruses responsible for various diseases of cultivated crops and fruit trees and to evolve measures for preventing and controlling such diseases. The Section has accumulated during the last thirty years a valuable collection of Indian parasite fungi and has also received from other countries numerous specimens of parasitic fungi of economic importance. There is a herbarium which has a large reference collection and is invaluable in the identification of diseases. A new addition to the equipment of the culture house is a large insect-proof house, part of which consists of glassed-in cubicles for the carrying out of pot-culture experiments.

The new Institute at Delhi is designed and equipped to meet the requirements of students, staff and other research workers whose ultimate purpose is to carry out advanced research in agricultural sciences. The post-graduate students and workers will be afforded every facility to obtain experience not only of the general work of the particular laboratory to which they are assigned but also of the whole Institute. They will be given the fullest opportunities for conducting original researches under proper supervision. They will also be made thoroughly conversant with the technique of field experiments which is the foundation on which the work of the Institute depends.

The Institute and the staff thereat are recognised by the several universities in India as a place from which theses for higher degrees can be submitted. The question of according some form of recognition to the post-graduate courses has been considered, and the Government of India have recently issued orders that those who have in the past satisfactorily completed the course in any of these subjects or who may do so in future will be regarded as 'Associates of the Imperial Agricultural Research Institute', and that the successful post-graduate students will be entitled to affix to their names the abbreviation 'Assoc. I.A.R.I.'.

The function of an all-India Institute is to tackle general problems and to lay foundations for detailed local work. It is, therefore, of importance to cultivators throughout the country that these should be studied in a central place which provides adequate contacts and opportunities for exchange of ideas and views with other scientific men and the general public interested in agriculture. It is hoped that the facilities at the Imperial Agricultural Research Institute, New Delhi, will attract not only those who have graduated in agriculture, but also workers in pure sciences, for, many investigations, though not primarily connected with agriculture, lend themselves to elaboration for solving the agricultural problems of India.

II. RESEARCH AND INVESTIGATIONS

Most of the experimental work was suspended preparatory to the transfer of the Institute to Delhi. The work of the Botanical Section was continued as usual, as the transfer of the Botanical Sub-station from Karnal to Pusa would permit continuance of the work on hand till the land at Delhi is fit for experimental work. The Agricultural Section was solely engaged on raising a money crop of sugarcane and fodder for cattle. Meanwhile at the Karnal sub-station preparations were on foot to extend the area under cultivation to resume the work of the Agricultural Section with the least possible delay. The scientific work in other Sections was confined to the completion of work on hand and to the extent necessary for the work of the post-graduate students under training.

1. Soils

Photo-nitrification in soils.—Further experimental work on the effect of sunlight and ultraviolet light on nitrification in soils with acid or alkaline reaction showed no evidence of photo-nitrification.

Acid soils.—A mixture of calcium carbonate and sodium carbonate is a better agent for correcting soil acidity than either calcium carbonate or sodium carbonate applied alone. In regions where acid soils are found, lime treatment is an expensive proposition, as it has to be imported in bulk from long distances. The use of sodium carbonate in such cases is likely to make amendment of soil acidity a less expensive proposition. The addition of lime to these acid soils results at first in a decrease in the moisture equivalent of the soil till the amount of lime added equals two-thirds of the lime requirement, and then begins to increase with increasing additions of lime.

The longevity of micro-organisms in soil.—Comparative studies on the nature and number of micro-organisms in fresh soils and in soils stored in bottles for thirty years showed considerable reduction in bacterial population but not in that of fungi. There was a total absence of nitrification in stored soils but the capacity for ammonification and for carbon-dioxide production did not appear to have diminished.

2. Manures and Fertilizers

Sann-hemp as green manure.—Further large-scale experiments on the economical methods of green-manuring with sann-hemp have given additional support to the previous observations. The tops of sann-hemp plants benefit the soil as much as when the whole plant is buried. It is, therefore, more economical to allow the crop to grow longer than usual and use the tops for green-manuring and the stems for fibre extraction.

Utilisation of Khudada phosphates.—These are natural phosphate deposits in Bihar. Their composition is such that it is uneconomical to convert the raw phosphate by itself into superphosphate but when used mixed with bonemeal it is likely to prove an economical proposition.

3. Crops

Cultivated area at Karnal.—The whole of the Karnal farm, which was formerly the Imperial Cattle Breeding Farm, having been taken over, from the 1st January 1936, as an Agricultural Sub-station of the Imperial Agricultural Research Institute at New Delhi, the area under home cultivation in the farm has been extended. Previously the area worked by the farm staff was

about 173 acres in all. From the 1st of April 1936, a further 294·39 acres which had been under cultivation by the Imperial Agriculturist and an area of 86·71 acres cultivated by the Imperial Economic Botanist have been added. An additional area of 380 acres has been redeemed from the *batai* system of cultivation by tenants and has been brought under direct cultivation. The total area now under direct cultivation by the farm staff is 934 acres.

Wheat.—The yield trials of Pusa 120 and Pusa 165 at a number of stations in the United Provinces and the Punjab were continued. According to the previous two years' results, Pusa 165 is one of the best yielding Pusa wheats. Pusa 120 has the tendency to shed grain when ripe but one great point in its favour is that in glasshouse tests it has shown itself to be very highly resistant to all the three physiological forms of yellow rust so far recorded in India. It should prove of considerable value as a parent for breeding rust-resistant wheats. Dr. K. C. Mehta's investigations on rusts of wheat having given data to enable breeding work for rust resistance to be initiated, a wheat-breeding section was incorporated in the scheme for investigations on cereal rusts; a large number of crosses has been made and from these a few have been selected for further breeding, the selection being based on the results obtained by Dr. Mehta on the resistance of parental types. The aim is not merely to obtain rust-resistant wheats, but also to evolve those which combine this capacity with other desirable economic qualities, such as early maturity which is of great importance in the Central Provinces, Bombay and certain other areas.

The demand for Pusa seed continues to be on the increase, and during the year under report it has gone beyond our capacity to supply. The indents for Pusa 4 seed from the Bombay Presidency and the Deccan rose to the total of 103,731 pounds. In the Jullundur Circle of the Punjab, Pusa 80-5 is rapidly becoming the favourite.

Barley.—Eight types of Pusa barleys of 1935 crop were again sent for a malting test to the Institute of Brewing, London. Shipments were made by two different routes—*via* Karachi and *via* Calcutta. Those shipped through Karachi are reported to contain 1½ per cent more moisture than those sent *via* Calcutta. These samples were also tested for malting values by the Imperial Agricultural Chemist in his laboratory. The results of analyses at the two places closely agree in regard to the relative merits of the different samples as malting barleys. A point to be noted is that samples of Pusa Type 21 grown in different districts of Bihar were distinctly different in malting value. Grown at Patna it was reported to be 'a good, mellow, thin-skinned barley and better than commercial barleys imported in recent years', whereas

the same barley grown at Sepaya was said to be a well developed but very ugly barley which would be rejected on appearance though suitable for distilling according to analyses. The same type sent from Pusa was reported to be a barley of common type and could not be recommended.

Potato.—In connection with the potato-breeding scheme, the main object of which is the production of new varieties with desirable characters—such as immunity or high resistance to blight and virus diseases, coupled with good keeping quality —the study was commenced of Indian and foreign material to discover the forms most likely to be of value as parents for crossing under Indian conditions. Experiments to discover the most suitable site for a Hill Sub-station were carried out at Simla, Murree Hills, Kulu Valley in the Punjab, Chaubattia (Ranikhet) and Khabrar (Ramgarh) in the United Provinces, and at Shillong in Assam. Flowering and berry formation were satisfactory at Simla, Chaubattia and in some places in the Kulu Valley. Simla was ultimately selected because of the easy availability of several facilities for the work of the station.

Sugarcane.—The sugarcane breeding work at the Breeding Station at Coimbatore continued with the usual vigour, and much new ground was explored.

The present need of sub-tropical India is an 'early' high tonnage cane. The existing types do not combine the two qualities. During the year it was possible to release for trial a few types combining earliness and fair tonnage.

The *Sorghum* hybrids are showing remarkable figures in the matter of sucrose, one of them recording over 21 per cent in bulk samples. The hopes entertained in the early years about early maturity being secured by crossing with *Sorghum* have not been realised under sub-tropical conditions. Under North Indian conditions good growth during rains would appear to depend on a fair amount of early growth in the plant by the end of summer. *Sorghum* hybrids do not show this character. It would now appear that the problem will have to be tackled on a wider basis for increasing vegetative vigour.

Cyto-genetic studies to ascertain the genetical and cytological 'make-up' of parents used in breeding work were undertaken and attention was paid to the development of a technique, and several useful observations were made.

An attempt was made during the year to study the chromosome structure and behaviour in the comparatively simpler forms of the genus *Saccharum* and to effect controlled crosses after proper emasculation. Several intraspecific crosses and intergeneric crosses and back crosses were made. The intergeneric

cross between *Saccharum spontaneum* and *Sorghum* has since flowered. The external characters and chromosome numbers leave no doubt about the genuineness of the cross. An interesting phenomenon revealed by the studies is that, whereas there is a doubling of chromosomes on the mother side in the case of certain crosses, such a doubling does not occur in others.

Among the thick canes, Co. 419 and Co. 421 are giving very good results at the testing stations, the former mainly in tropical and the latter in sub-tropical areas. Co. 419 recorded much higher yields than the well-known P.O.J. 2878 at Padegaon in the Bombay Presidency. Co. 421 showed itself the leading cane at the Karnal sub-station and is in favour in the North Indian stations. Co. 213 showed marked resistance to frost in Sind, as also Co. 281 and Co. 270. Co. 223 in the Punjab has again shown good ratooning characteristics. Co. 331 is one of the new canes which is being developed in the United Provinces for wide cultivation under tube well irrigation as a late season cane.

Two seedlings—Co. 270 and Co. 310—are coming into favour outside India. The latter has recently been released for commercial planting in Natal. It is interesting to observe that Co. 290 and its cousins are attracting attention in Australia as fodder canes and are replacing the old Japanese types. The canes are chopped fine (1-8 inch to 3/8 inch lengths), mixed with bran and molasses, and fed to cattle.

Further work on the effect of arrowing of canes under Coimbatore conditions confirmed the previous findings (1) that arrowed canes register improvement in juice quality, in some cases for about two months after the short blade stage, and (2) that non-arrowed canes show considerable increase in weight long after the arrowed canes of the same variety have ceased to add weight.

4. Insect Pests and Diseases of Crops

Among investigations and observations on insect pests, some valuable information relating to insect pests and parasites on sugarcane was collected. At Pusa all the three species of *Pyrilla*, *P. aberrans*, *P. pusana and P. perpusilla*, were found, but *P. pusana* was the most common from July onwards to the end of the season. As observed in previous years, the increased humidity of the air at this time of the year seemed to help the pests in their rapid multiplication.

The sugarcane whitefly (*Aleurolobus barodensis*) also multiplied with alarming rapidity during the monsoon months. The infestation by this pest was particularly severe in the ratoon area. All the varieties under observation were susceptible to attack.

The Chalcid parasites *Tetrastichus pyrillæ* and *Ooencyrtus pyrillæ* were the first to appear in the field about the 3rd week in July. The bionomics of these parasites were under study. Parasitisation of exposed eggs on the exposed green leaves was much

higher than of those laid inside the sheathing leaves. The periodical removal of leaf-sheaths would appear to be useful in reducing the number of the pests by parasitisation. The Dryinid parasites of *Pyrilla* made their first appearance in September.

Among borers, the stem-borer causes the maximum amount of damage both in regard to the quantity and quality of the crop. The top-borer is next in importance. The loss sustained by the attack of termites is variable. The root-borer in the early stage of the crop is harmful but afterwards it is in no way detrimental to the crop, either in regard to tonnage or the quality of the juice.

Sugarcane Mosaic.—Investigations showed that the thermal-death-point of mosaic virus appears to vary with the variety of cane. Saretha mosaic virus tested with maize as the test plant was inactivated at or a little above 50°C. Other varieties like M. 16 and Co. 313 did not show appreciable loss of infective power when heated at 50°C., but further heating at 60°C. inactivated Co. 313 virus while M. 16 still retained some infective power. The thermal-death-point of the mosaic virus of Co. 213 lay between 40°C. and 45°C. The investigations on the infectivity of mosaic so far carried out suggest that the infective principle is closely associated with chlorophyll.

Exhaustive experiments spread all over the year were carried out in attempts to secure fresh isolations of the organism found to be associated with mosaic virus and having a visible cyclostage. Neither 'opalescence' nor 'cyclostage' has been met with in any of the experiments attempted so far. In one isolated case, however, some growth was observed after three weeks, but further sub-culturing produced no growth.

5. The Sahiwal Dairy Herd

The average milk yield per cow per day for the year under report was 21·2 lb., as compared with 19·1 lb. during the previous year. This improvement on previous years is the result of the producing power shown by the heifers coming into milk, while the second calvers also showed an improvement on the average of past year. The early maturity experiments were continued, and it may be noted here that the majority of the improvement recorded in the milk yield is attributable to early maturity heifers and second calvers. The health and condition of the calves continue excellent, and so far there is no justification for fears of deterioration and lack of vigour which early maturity is supposed to bring about.

6. Programme of Work

At the new site a detailed soil survey of the cultivable area and its mapping will be undertaken. This work forms the basis of all

experimental work. The analyses and tests on the soils will be carried out by all the methods available at present, and this information will be carefully recorded and mapped with a view to correlate the soil's future behaviour and crop response with the results of several methods employed in the study of soils and subsoils. The periodic changes in the composition and levels of subsoil water in the area will also be studied. For a new research station these studies will also be of considerable value in investigations on the technique of field experiments.

As the land at Delhi will not be fit for work for some time yet, the Agricultural Section will continue its work on crop husbandry at its sub-station at Karnal.

The Botanical Section will continue its work on breeding and genetics of wheat, barley, oats, maize, potatoes, pulses, oil-seeds and tobacco at its sub-stations at Pusa, Simla and Guntur.

The Chemical Section will be engaged on the study of the soils for their physical, chemical and micro-biological properties. In collaboration with the Agricultural Section investigations on the resistance of soil to bullock-drawn implements will be carried out. It will also collaborate with the Agricultural Section in the special feeding of young stock with reference to early maturity in the Sahiwal breed.

The Entomological Section will study the insect fauna and pests of the area and will specially interest itself in the pests of cotton and sugarcane.

The Mycological Section will carry out the survey of plant diseases in the neighbourhood of Delhi. It will carry out varietal tests with improved types of sugarcanes for their resistance to mosaic.

The main Sugarcane Breeding Section at Coimbatore and its sub-station at Karnal will engage themselves on sugarcane breeding to effect further improvement in yield and quality; they will also investigate the causes of sterility in sugarcane flowering and will pay particular attention to root-development; cyto-genetic and morphological studies of the genus *Saccharum* will be continued and extended.

III. GENERAL ADMINISTRATION

Charge.—Dr. F. J. F. Shaw, the permanent Director of the Institute, was appointed to officiate as Agricultural Expert to the Imperial Council of Agricultural Research with effect from the 26th October, 1935, and Rao Bahadur B. Viswa Nath took over as Officiating Director. The post of Joint Director was held by

Rao Bahadur B. Viswa Nath until the 13th October 1935 when Mr. Wynne Sayer returned from leave *ex*-India.

Honours.—On the occasion of the birthday of His Majesty the King and Emperor of India, Dr. Shaw was decorated with C.I.E.

Obituary.—It is sad to record that Dr. Shaw did not live to wear the honour which he so richly deserved. His death on the 29th July 1936 is an irreparable loss to the Institute for which he gave his best and closes to Indian Agriculture a career of service rich in accomplishment and a record of sustained distinction.

Staff.—Owing to absences on leave, etc., the following changes in the charge of Sections were made :—

Agricultural Section.—Mr. Arjun Singh up to 13th October 1935, *vice* Mr. Wynne Sayer on leave who has been confirmed in the post of Imperial Agriculturist.

Botanical Section.—Dr. B. P. Pal from the 26th October 1935, *vice* Dr. F. J. F. Shaw on other duty.

Sugarcane Station.—Mr. N. L. Dutt from the 2nd August to the 24th October 1935, *vice* Rao Bahadur Venkataraman on deputation, and again from the 9th to 23rd December 1935 when the Rao Bahadur was on leave.

Deputations.—Rao Bahadur T. S. Venkataraman, Sugarcane Expert, was deputed for a little over 2½ months to Australia to attend the Fifth Congress of the International Society of Sugarcane Technologists. The Rao Bahadur was permitted to revisit Java during the return journey.

Dr. Miss Janaki Ammal, Sugarcane Geneticist, was deputed to attend the International Botanical Congress at Amsterdam and the Imperial Botanical Congress at London, and to work for two months at the John Innes Horticultural Institution, Merton. This involved a total period of absence out of India for a little over four months.

Mr. P. V. Isaac, 2nd Entomologist, attended the Fourth Imperial Entomological Conference held in London from the 26th August to the 2nd September 1935. On the termination of the Conference, in view of his selection to be placed in charge of a central research scheme on the insect pests of sugarcane financed by the Imperial Council of Agricultural Research, Mr. Isaac was deputed, for a period of 3½ months, to visit America (Louisiana), Porto Rico and Hawaii to study sugarcane pests occurring in these countries and the methods of biological control pursued. Mr. Isaac returned to India on 9th February 1936 and was immediately placed in charge of the sugarcane pests scheme.

Separation of Imperial Institute of Animal Husbandry and Dairying.—With effect from 1st April 1936, the Physiological Chemist and his Section have been transferred under the administrative control of the Director, Imperial Institute of Veterinary Research, and an Imperial Dairy Department has been created with the Imperial Dairy Expert as its head. The Imperial Cattle Breeding Farm at Karnal has been left with the Imperial Department of Agriculture to function as a sub-station of the New Delhi Institute.

Schemes of Research financed by the Imperial Council of Agricultural Research.—Besides the six schemes mentioned in last year's report which were under operation, two more schemes were sanctioned during the year. One is for research into the insect pests of sugarcane and the other for the establishment of a sub-station at Guntur for work on cigarette tobacco. In view of the need for a careful and detailed study of the chemistry of sugarcane a scheme to carry out investigations in this line was also sanctioned after the close of the year.

Training.—There were 33 candidates for admission to the post-graduate courses beginning in November 1935, of whom 18 were recommended by Provincial authorities for nomination of students. Thirteen applicants were selected for admission : four in Botany, four in Agricultural Chemistry, of whom one left on getting an appointment soon after joining, one in Entomology, one in Mycology and three in General Agriculture. During the year under report seven post-graduates completed the two-year course ; four in Botany, two in Agricultural Chemistry and one in Entomology. The one-year course in farm organisation, farm management and general farm engineering was completed by three students.

Mr. T. R. Ayyangar and Mr. T. Varahalu obtained their M. Sc. degrees on thesis prepared under the guidance of officers of the Institute. Another worker Mr. S. V. Ramanayya has submitted his thesis to the Andhra University.

A special course in the flue-curing of tobacco lasting for two months was organised at Pusa during the winter of 1936. It was attended by one candidate from Bihar, two from the Gwalior State and one from the Kashmir State.

Library.—Publications received in exchange numbered 979, while 281 were purchased. As the Library had to be packed for transfer to New Delhi, the issue of books on loan was suspended for part of the year. Over 1,400 books were, however, issued on loan, of which 120 were sent to scientific workers in the Provinces and Universities.

IV. ACCOUNTS

The total expenditure of the Institute and its out-stations at Karnal and Coimbatore during the financial year ending 31st March, 1936, amounted to Rs. 6,75,360—

Name of Establishment	Expenditure
	Rs.
General expenditure of the Institute, including the office of the Director, Power and Gas plants, the Medical and Estate Establishments.	1,99,622
Agricultural Section	1,29,650
Botanical Section	38,373
Chemical Section	70,736
Entomological Section	49,016
Mycological Section	37,594
Agricultural Sub-station, Karnal	62,811
Sugarcane Station, Coimbatore	84,744
Works (Petty)	2,814
Total	6,75,360

The cost of the Botanical and Sugarcane Sub-stations at Karnal, the Potato Breeding Station at Simla, and the schemes for research on mosaic and other diseases of sugarcane and genetics of sugarcane amounting to Rs. 23,733, Rs. 8,492, Rs. 6,000, Rs. 12,786, and Rs. 5,347, respectively, was met from the funds of the Imperial Council of Agricultural Research.

The receipts of the Institute and its out-stations amounted to—

	Rs.
Pusa Institute	55,787
Agricultural Sub-station, Karnal	29,032
Sugarcane Station, Coimbatore	8,574
Botanical Sub-station, Karnal	3,196
Sugarcane „ „	1,312
Total	97,901

22nd October 1936.

REPORT OF THE IMPERIAL AGRICULTURIST

[WYNNE SAYER, B.A., DIP.AGRI. (CANTAB.)]

1. AGRICULTURAL SECTION, PUSA

I. CHARGE

Mr. Wynne Sayer was confirmed in the post of Imperial Agriculturist and held charge of the Section for the year with the exception of the period of his leave up to 13th October 1935, when Mr. Arjun Singh, Assistant Agriculturist, was in charge of the Section in addition to his own duties.

Messrs. L. S. Joseph and P. V. Krishna Iyer held the posts of Cattle Superintendent and Statistician, respectively, throughout the year. Mr. P. V. Krishna Iyer was confirmed in the Class II post of Statistician with effect from the 12th November 1935.

Mr. S. M. Jamaluddin, Second Cattle Superintendent, was transferred to Karnal to officiate as Superintendent, Agricultural Substation, from the 1st March 1936.

II. TRAINING OF POST-GRADUATE STUDENTS

Three post-graduate students, Messrs. Anand Mohan Sinha, Prabhunath Prasad and Sukhsagar Lal Gupta, completed their training in general agriculture and farm organisation on the 31st October 1935. Mr. K. K. Achan, from the Animal Husbandry and Dairy Section, finished his course on the 31st March 1936.

Messrs. Mohamad Hussain (Punjab), K. K. Khosla (Patiala State), and Syed Mudassir Ali (Assam) were taken for one year's course in general agriculture and farm organisation from the 1st November 1935.

III. SEASON AND CROPS

The total rainfall during the year, from the 1st June 1935 to the 31st May 1936, amounted to 43·64 inches as against 41·33 inches in the corresponding period of the previous year. The season was marked by three abnormal factors—(i) unusually short rainfall (4·93 inches) during the month of July 1935, (ii) high floods in the month of September 1935 and (iii) failure of winter rains, the effect of which on the various crops is seen from the accompanying statement.

Yield of principal crops grown on the farm

Crop	Area in acres	Yield in maunds *	
		Total	Average per acre
Maize—corn	21·60	312·32	14·46
Maize—green fodder	80·72	11,203·15	138·79
Maize & pulses—green fodder	155·28	12,562·73	80·90
Wheat	4·50	25·85	5·74
Barley	9·00	49·79	5·53
Oats	262·59	2,588·20	9·86
Gram	3·58	37·55	10·49
Peas	4·00	40·01	10·00
Arhar (*Cajanus indicus*)	4·05	58·32	14·40
Soybean—seed	7·00	64·65	9·23
Soybean—green fodder	1·00	95·13	95·13
Meth (*Phaseolus aconitifolius*)	4·00	40·38	10·10
Berseem—green fodder	90·90	24,367·08	268·06
Sugarcane (Farm)	203·46	84,749·83	416·54
Sugarcane (New Area)	114·27	31,770·73	278·03

* 1 maund = 82·28 lb.

IV. SEED SUPPLY

The demand for seed of improved crops was greater than ever, but, owing to curtailment of activities in view of the transfer to New Delhi, full indents could not be met.

The details of supply are given below :—

Crop	Quantity lb.
Oats	4,114·00
Soybean	691·16
Maize	534·82
Meth	621·19
Cowpeas	164·56
Sugarcane—	
Co. 281.	22,256·74
Co. 299.	319,534·38
Co. 313.	624,587·48
Co. 331.	417,200·74
New varieties	3,702·60

V. FIELD EXPERIMENTS

In view of the impending transfer of the Institute to Delhi, the experimental work of the Section was almost entirely closed down. The following experiments were conducted during the year under report, and their results are discussed briefly seriatim.

1. Manurial Experiments

(*i*) *Permanent manurial and rotation experiments in the Punjab field, Blocks C. & D.*—These experiments were continued as before according to the new scheme laid down by the Board of Agriculture in 1929. The yields obtained from different plots are given in the table below :—

Results of permanent manurial and rotation experiments for the year 1935-36.

Treatment	A Series			B Series		
	Kharif 1935	Rabi 1935-36		Kharif 1935	Rabi 1935-36	
	Maize grain per acre	Barley grain per acre	Wheat grain per acre	Maize grain per acre	*Rahar* grain per acre	Barley grain per acre
Group I	lb.	lb.	lb.	lb.	lb.	lb.
1. No manure (check plot No. 1).	964	176	..	332	628	..
2. Farmyard manure at 4,000 lb. per acre.	1,692	356	..	924	1,090	..
3. Farmyard manure at 8,000 lb. per acre.	2,100	460	..	896	1,520	..
4. Farmyard manure at 4,000 lb. per acre *plus* rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	2,052	552	..	1,496	1,376	..
5. Rape cake at 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at last interculture.	1,460	516	..	1,020	958	..
Group II						
6. Sulphate of ammonia at 40 lb. nitrogen per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	544	372	..	168	828	..

Treatment	A Series			B Series		
	Kharif 1935	Rabi 1935-36		Kharif 1935	Rabi 1935-36	
	Maize grain per acre	Barley grain per acre	Wheat grain per acre	Maize grain per acre	*Rahar* grain per acre	Barley grain per acre
	lb.	lb.	lb.	lb.	lb.	lb.
GROUP II—*contd.*						
7. Sulphate of potash at 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* crop is sown it is to be applied in one dose in *kharif*.	552	264	..	152	702	..
8. Superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	620	566	..	104	1,880	..
9. Sulphate of potash at 50 lb. K_2O per acre and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	664	254	..	248	1,838	..
10. Sulphate of ammonia at 40 lb. nitrogen, sulphate of potash at 50 lb. K_2O and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	948	668	..	256	2,008	..

Treatment	A Series			B Series		
	Kharif 1935	Rabi 1935-36		Kharif 1935	Rabi 1935-36	
	Maize grain per acre	Barley grain per acre	Wheat grain per acre	Maize grain per acre	*Rahar* grain per acre	Barley grain per acre
	lb.	lb.	lb.	lb.	lb.	lb.
GROUP II—*concld.*						
11. Sulphate of ammonia at 40 lb. nitrogen and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	312	588	..	92	2,054	..
13. No manure (Check plot No. 2).	292	608	..	92	700	..
14. Sulphate of ammonia at 40 lb. nitrogen per acre, sulphate of potash at 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	292	488	..	132	698	..
GROUP III						
12. Green manure in conjunction with a purely cereal rotation.	Green manure	..	646	Green manure	..	722
15. Effect of green manure and leguminous crop in the rotation.	Green manure	924	..	772	702	..
16. As for plot No. 15 but with an additional application of superphosphate at 80 lb. P_2O_5 per acre to be applied with green manure only.	Green manure	2,476	..	1,168	1,400	..
17 No leguminous crop and no green manure.	620	..	86	352	..	192
1-. No manure (Check plot No. 3).	636	232	..	348	692	..

(*ii*) *New manurial and rotation experiment in the Punjab field, Block A.*—This experiment was initiated during 1932-33 on the lines of the preceding experiment; the first cycle of a four-year eight-course rotation, as detailed in the report of 1932-33, was completed during the year under review. The following are the results of the experiment :—

Treatment per acre	Mean yield per plot in lb.		Per cent on control	
	Maize No. 1	Gram P. F. 3	Maize No. 1	Gram P. F. 3
A. No manure (control) . .	5·990	13·983	100·0	100·0
B. Farmyard manure * at 8,000 lb.	10·582	24·603	176·7	176·0
C. Rape cake at 40 lb. N. . .	14·125	19·690	235·8	140·8
D. Amm. sulphate at 40 lb. N .	7·331	12·971	122·4	92·8
E. Pot. sulphate at 50 lb. K_2O .	5·650	12·720	94·3	91·0
F. Superphosphate at 80 lb. P_2O_5 .	6·276	21·652	104·8	154·9
G. Pot. sulphate at 50 lb. K_2O and Superphosphate at 80 lb. P_2O_5.	5·401	19·156	90·2	137·0
H. Amm. sulphate at 40 lb. N, Superphosphate at 80 lb. P_2O_5, Pot. sulphate at 50 lb. K_2O.	10·827	20·896	180·8	149·4
I. Amm. sulphate at 40 lb. N and Superphosphate 80 lb. P_2O_5 .	9·945	21·826	166·0	156·1
J. Amm. sulphate at 40 lb. N and Pot. sulphate at 50 lb. K_2O.	8·689	12·264	145·1	87·7

Fisher's 'z'-test was applied, and the general effect of treatments was found to be significant at the one per cent level. Fisher's 't'-test was also applied, and the results were as follows :—

Maize

Critical difference = 3·139 (P = ·01)

Critical difference = 2·368 (P = ·05)

Conclusions : C > H = B = I = J > D = F = A = E = G

Gram

Critical difference = 6·019 (P = ·01)

Critical difference = 4·540 (P = ·05)

Conclusions : B > C, G, A, D, E & J ;

I = F = H = C = G > A = D = E = J

From the scrutiny of the last four years' results, it is found that sulphate of potash has a depressing effect on cereals and legumes, while organic manures and a combination of nitrogenous fertilizer with phosphate generally give better yields.

*Composition of farmyard manure :—
N = 0·52 per cent, P_2O_5 = 0·46 per cent and K_2O = 0·895 per cent.

(*iii*) *Green-manuring experiment in the Punjab field, Block B.*—The experiment was carried out on the lines given in two previous reports. The results are tabulated below :—

Treatment	Mean yield per plot of wheat grain P. 52 (Area of each plot = 0·03 acre)	Per cent on general mean	'z'-test	Critical difference
	lb.			
T. 1—Sann-hemp .	27·93	148·69	Significant at the 1 per cent level	6·35 (P = ·01)
T. 2—Cowpeas . .	15·48	82·41		
T. 3—*Guar* (*Cyamoopsis psoralioides*).	24·23	128·99		
T. 4—*Meth* . .	12·70	67·61		
T. 5—Soybean . .	15·41	82·02		
T. 6—Velvet-bean .	16·96	90·28		

Conclusions :—T. 1 = T. 3 > T. 2 = T. 4 = T. 5 = T. 6.

From the above results, it is evident that sann-hemp, *guar* and velvet-bean are better green-manuring crops than other legumes, and this result is in conformity with that obtained last year.

(*iv*) *Manurial experiment with silt and farmyard manure on sugarcane in Harpur Jhilli.*—The preliminary experiments with river silt for manuring sugarcane, as discussed in the last two reports, revealed the necessity of further trial on a properly designed lay-out. The manures were tried in paired plots arranged according to Beaven's half-drill-strip method with twelve replications for each treatment. The details of statistical analysis and the composition of manures are given below :—

Variety of sugarcane . . . . . = Co. 210.
Area of each plot . . . . . = 1/20 acre.
Mean difference in favour of farmyard manure . = 452·75 lb.
Standard error . . . . . = 99·88
Critical difference (P = ·01) . . . . = 310·22
Result :—Farmyard manure > Silt
Sucrose per cent in juice (January) F. Y. M. 12·49; Silt 13·12

Chemical analysis of silt and farmyard manure

Manure	N per cent	P_2O_5 per cent	K_2O per cent
Silt	0·03	0·10	0·46
Farmyard manure	0·521	0·196	0·536

The usual dose of farmyard manure, at 14 tons per acre, was applied about two months before planting, and silt was also added

at the same time, on an equal cost basis, at 28 tons per acre. Though the results of two previous years indicated a better prospect for silt, it was, however, not maintained in the present year.

(*v*) *Sugarcane manurial and rotation experiments with Co. 210 in Harpur Jhilli.*—It is generally believed that a close cane rotation, such as cane-fallow-cane, usually tends to exhaust the land. An experiment designed to maintain the land in the best possible condition for such a type of rotation was started after the harvest of cane in the above field in February 1932. The results of the first experiment (1933-34) have already been published ; the procedure adopted in the second trial was exactly the same as before. The treatments (per acre) received by the soil are detailed below :—

A. Fallow in *kharif* (1934) and 14 tons farmyard manure at the end of monsoon.

B. Fallow in *kharif* (1934) and complete minerals (40 lb. N as amm. sulphate, 50 lb. P_2O_5 as superphosphate and 40 lb. K_2O as pot. sulphate) applied at the time of planting cane.

C. Sann-hemp sown in *kharif* (1934) and ploughed in after eight weeks with 50 lb. P_2O_5 as superphosphate. 40 lb. N as rape-cake applied at the time of planting cane.

D. Sann-hemp sown in *kharif* (1934) and ploughed in after eight weeks. Complete minerals (as in treatment B) applied at the time of planting cane.

E. Fallow in *kharif* (1934) and standard manure (40 lb. N as rape-cake and 50 lb. P_2O_5 as superphosphate) applied at the time of planting cane.

The following results have been obtained from the present experiment :—

Treatment	Sucrose per cent (Decr.)	Mean tonnage yield per plot (Area of each plot =0·045 acre)	Per cent on general mean	'z'-test	Critical difference
		lb.			
A	11·62 2·63	2677·75	10 ·4	Significant at the 1 per cent level	123·08 (P = ·01)
B	13·22 13·37	2299·70	91·3		
C	12·16 13·20	2611·30	103·7		91·23 (P = ·05)
D	12·02 12·76	2564·60	101·9		
E	13·87 14·69	2433·45	96·7		

Conclusions :—A > B, D & E ; C > B & E ; D > B & E ; E > B.

It will be seen that these results are in complete agreement with those obtained before.

(*vi*) *Sugarcane manurial experiment in the New Area, Waini Block.*—A complex experiment was initiated during the year with eleven treatments (including a control) and three standard varieties of sugarcane. The experiment was laid down in three "randomised blocks" with nine replications for treatment and 33 for variety. The effective area of each plot was 1/30 acre. The field was green-manured in *kharif* 1934.

Treatments per acre :—

	Tons
T. 1—Farmyard manure	10
T. 2—Village bulk manure (F. Y. M.)	10
T. 3—Farmyard manure	14
T. 4—Cattle standings	14
T. 5—River silt	28
T. 6—Tank soil	28

T. 7—Standard manure :—
40 lb. N as rape cake.
50 lb. P_2O_5 as superphosphate.

T. 8—Complete minerals :—
40 lb. N as amm. sulphate.
50 lb. P_2O_5 as superphosphate.
40 lb. K_2O as pot. sulphate.

T. 9—Superphosphate . . . . . 75 lb. P_2O_5
T. 10—Amm. sulphate . . . . . 80 lb. N
T. 11—No manure (Control)

Varieties :—

A—Co. 210

B—Co. 213

C—Co. 331

Chemical analysis of manures

Manures	N per cent	P_2O_5 per cent	K_2O per cent
Farmyard manure	0·521	0·196	0·536
Village manure	0·27	0·40	1·07
Silt	0·03	0·10	0·46
Tank soil	0·08	0·09	0·78
Cattle standings	0·05	0·16	0·96

A summary of results is given in the following tables :—

Analysis of variance

Variance due to	D. F.	Sum of squares	Mean square	S^2_1/S^2_2	
				Calculated value	Theoretical value
Blocks	2	106125·6	53062·8	1·646	3·142 (5%)
Treatments	10	2145024·7	214502·5	6·655	2·642 (1%)
Varieties	2	11300507·4	5650253·7	175·294	4·956 (1%)
Interaction :—					
Treatment × Variety	20	1131733·7	56586·7	1·756	1·761 (5%)
Error	64	2062913·7	32233·0	..	..
Total	98	16746305·1	..	..	..

Significance of treatments

Treatment	Sucrose per cent (February)	Mean yield per plot	Per cent on control	Critical difference
		lb.		
T. 1	14·93 14·13 15·07	1333·6	126·87	224·7 (P = ·01)
T. 2	13·93 15·32 15·29	1455·3	138·46	169·1 (P = ·05)
T. 3	14·70 15·54 16·00	1327·4	126·29	
T. 4	14·57 15·56 16·07	1173·0	111·60	
T. 5	15·29 16·02 16·84	1146·1	109·04	
T. 6	15·14 16·70 15·91	1078·2	102·58	
T. 7	14·65 13·19 15·28	1460·9	138·99	
T. 8	13·66 15·04 16·33	1275·0	121·30	
T. 9	13·75 15·46 16·39	1288·2	122·56	
T. 10	15·40 15·18 16·04	1020·6	97·09	
T. 11	15·60 15·61 16·81	1051·1	100·00	

Conclusions :—T. 1 = T. 2 = T. 3 = T. 7 > T. 5 = T. 6 = T. 10 = T. 11 ; T. 2 = T. 7 > T. 4, T. 8 & T. 9 ; T. 8 = T. 9 > T. 6 = T. 10 = T. 11.

Significance of varieties

Variety	Mean yield per plot	Per cent on general mean	Critical difference
	lb.		
Co. 210	1216·0	98·28	117·3
Co. 213	834·5	67·45	(P = ·01)
Co. 331	1661·2	134·27	

Conclusions :—Co. 331 > Co. 210 > Co. 213.

In this experiment also, the superiority of farmyard manure and ' standard manure ' to other treatments is established.

(*vii*) *Green-manuring experiment with berseem on sugarcane ratoon* (*Co. 213*) *in the New Area, Dholi Block.*—After the harvest of plant crop of the experiment started last year, first ratoon was raised to see the residual effect of manures applied to various plots before planting. The crop was harvested in November, and the following results were obtained :—

Treatment per acre	Mean tonnage yield per plot (area of each plot = 0·05 acre)	Per cent on general mean	' z '-test	Critical difference
	lb.			
T. 1 Berseem green manure. .	275·8	86·9	Not signi-	63·92
T. 2 Standard manure . .	302·4	95·3	ficant	(P = ·05)
T. 3 Ten tons farmyard manure .	320·7	101·1		
T. 4 Twenty tons farmyard manure	362·2	114·1		
T. 5 Complete minerals . .	325·5	102·6		

Conclusions :—T. 4 > T. 1.

It may be mentioned here that similar results were also obtained last year.

2. Varietal Yield Trials

(*i*) *Yield trial with soybean for fodder and seed in the Punjab field, Blocks B & D.*—After two years' trial, these experiments were concluded during the present year. The results arrived at were exactly the same as before.

Variety	Mean yield per plot (area of each plot = 0·019 acre)	Per cent on general mean	'z'-test	Critical difference
	lb.			
Fodder				
No. 1—Yellow	137·125	97·99	Significant at the 1 per cent level	14·645 (P = ·01) 10·552 (P = ·05)
No. 2—Chocolate . . .	156·708	111·98		
No. 3—Black	126·000	90·04		
	(Area of each plot = 0·015 acre)			
Seed				
No. 1—Yellow	19·66	112·39	Significant at the 1 per cent level	2·30 (P = ·01)
No. 2—Chocolate . . .	20·03	114·53		
No. 3—Black	12·78	73·08		

Conclusions :— Fodder—No. 2 > No. 1 > No. 3.
Seed—No. 1 = No. 2 > No. 3.

(*ii*) *Yield trial with field peas* (*Pisum arvense*) *in the Punjab field, Block B.*—The results of the third year's trial are given below :—

Variety	Mean yield per plot (area of each plot = 0·019 acre)	Per cent on general mean	'z'-test	Critical difference
	lb.			
P. F. 6	13·82	114·93	Not significant	3·84 (P = ·05)
P. F. 7	10·19	84·79		
P. F. 8	12·06	100·28		

Conclusions :—Differences between the varieties are not significant.

(*iii*) *Yield trial with peas* (*Pisum sativum*) *in the Punjab field, Block B.*—This experiment was also conducted on the lines given in the former reports :—

Variety	Mean yield per plot (area of each plot = 0·022 acre)	Per cent on general mean	'z'-test	Critical difference
	lb.			
P. F. 1	18·66	92·97	Significant at the 1 per cent level	8·30 (P = ·01)
P. F. 2	25·96	129·33		6·00 (P = ·05)
P. F. 3	23·32	116·16		
P. F. 4	12·35	61·54		

Conclusions :—P. F. 2 > P. F. 1 & P. F. 4 ; P. F. 3 > P. F. 4.
P. F. 1 > P. F. 4.

(*iv*) *Tonnage yield trial with sugarcane varieties Co. 213 and Co. 331 in the New Area, Harpur A.*—The experiment was laid down according to Beaven's half-drill-strip arrangement with 15 replications for each variety. The crop was allowed to stand over and harvested in March.

	lb.
Area of each plot = 1/20 acre	
Mean difference in favour of Co. 33	= 753·73
Standard error	= 68·28
Critical difference (P = ·01)	= 203·28
Result—Co. 331 > Co. 213.	

(*v*) *Tonnage yield trial with sugarcane varieties Co. 210 and Co. 213 in the New Area, Waini Block.*—The sixth year's trial with these varieties was concluded in favour of Co. 210. The experiment was carried out, as before, in paired plots arranged according to Beaven's half-drill-strip method with 12 replications for each variety.

	lb.
Area of each plot = 1/20 acre	
Mean difference in favour of Co. 210	= 532·58
Standard error	= 84·49
Critical difference (P = ·01)	= 262·42
Result—Co. 210 > Co. 213.	

3. Miscellaneous Experiments

(*i*) *Spacing experiment with maize P. F. 2 for fodder and corn in the Punjab field, Block D.*—The third year's experiment was based

on the lines given in the preceding reports. The spacing of nine inches within rows, as shown below, gave satisfactory results

Spacing	Mean yield per plot (area of each plot = 0·016 acre)	Per cent on general mean	'z'-test	Critical difference
	(lb.)			
For fodder T. 1—9 inches . .	335·63	108·27	Significant at the 1 per cent level	38·473 (P = ·01)
T. 2—12 ,, . .	322·44	104·02		27·820 (P = ·05)
T. 3—15 ,, . .	291·00	93·88		
T. 4—18 ,, . .	290·88	93·84		
For corn T. 1—9 inches . .	19·47	110·8	Significant at the 1 per cent level	3·213 (P = ·01)
T. 2—12 ,, . .	17·91	101·9		2·323 (P = ·05)
T. 3—15 ,, . .	17·85	101·5		
T. 4—18 ,, . .	15·09	85·8		

Conclusions :—Fodder—T. 1 = T. 2 T. 3 = T. 4.

Corn—T. 1 = T. 2 = T. 3 > T. 4.

(*ii*) *Experiments on the spacing of sugarcane rows and arrangement of setts at planting with Co. 210 in the New Area, Waini Block.*— The results of the present experiment have confirmed the conclusions reached before. The spacing of 2½ feet is not advantageous, as more setts are required. Further, the arrangement of 'eye to eye' at planting with ordinary seed is advisable and 'end to end' with good setts is equally sound.

Treatment	Average tonnage yield per acre	'z'-test	't'-test
	(lb.)		
3 ft. spacing	33,072	Not significant	Not significant
2½ ft. spacing	34,620		
End to end	33,608	Do.	Do.
Eye to eye	34,083		

(*iii*) *Isolation of pure types of cowpeas.*—About 368sam ples of cowpeas were received from all parts of India and Burma in response to a request made by the department for the above work. The investigation is intended for the Royal Botanic Gardens, Kew, and has been taken up at the initiation of the Imperial Council of Agricultural Research. About 183 foreign samples of cowpeas were also received from Kew for this work.

The investigation has been started this year.

4. Experiments conducted for other Sections of the Institute

The following field experiments were carried out for other Sections and their results have been dealt with in the respective reports.

(*a*) *Imperial Entomologist*

(*i*) The effect of borers on the tonnage yield and juice of the following varieties of sugarcane : Co. 210, Co. 213, Co. 299, Co. 313 and Co. 331.

(*ii*) The effect of borers and termites on the germination and yield of the above varieties, the setts being treated with (1) lead arsenate, (2) copper sulphate, (3) creosote, and (4) formalin, before planting.

The above experiments were laid down in Harpur Jhilli.

(*b*) *Imperial Mycologist*

(*i*) Experiments on the effect of mosaic on the tonnage yield and juice of Co. 213.

(*ii*) Experiments to examine the susceptibility to mosaic of Co. 214, Co. 285, Co. 299, Co. 331, Co. 387, Co. 388. Co. 393, Co. 395, Co. 396 and Co. 397.

Both these experiments were carried out in the silk-house area.

VI. SUGARCANE VARIETAL WORK

The importation of new varieties of sugarcane from Coimbatore and their testing and multiplication were continued as in previous years.

An area of 311·789 acres was put under the standard varieties of sugarcane during 1935-36 and were grown on a commercial scale. The statement given below shows the area and yield of sugarcane obtained from different fields.

Name of field	Area in acres	Tonnage yield (Mds.)*	Average yield per acre (Mds.)*
Ratoon crop—			
Gonhri	11·506	2634·00	228·93
New Area	26·321	4122·20	156·61
Plant crop—			
Gonhri	27·900	10900·83	390·71
Old Jhilli	26·460	10600·68	400·63
Brickfields	59·130	23048·75	389·80
Harpur Jhilli	47·902	23529·83	491·21
Janghat	8·500	4119·50	484·65
Phatak	13·720	6450·25	470·13
Bhograsan	5·400	2546·50	471·57
New Area	84·950	26691·90	314·21

* One maund = 82·28 lb.

The following varieties were under multiplication in the nursery at New Area :—

(*a*) Varieties imported from Coimbatore in 1931 :—Co. 347 and Co. 348.

(*b*) Varieties imported from Coimbatore in 1932 and 1933 :—Co. 366, Co. 368, Co. 369, Co. 370, Co. 371, Co. 374, Co. 375, Co. 377, Co. 378, Co. 381, Co. 382, Co. 384, Co. 386, Co. 391, Co. 394, Co. 412, Co. 413, Co. 417, and Co. 419.

(*c*) Varieties imported from Coimbatore in 1934 :—Co. 420, Co. 421, Co. 422, Co. 423, Co. 424, Co. 425, Co. 426, Co. 427, Co. 428, Co. 429, Co. 430, Co. 431, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 511, Co. 512, Co. 513, Co. 514, Co. 515 and Co. 516.

(*d*) Varieties imported from Coimbatore in 1935 :—Co. 432, Co. 433 and Co. 434.

Owing to the imminent transfer of the Institute to Delhi, the New Area was discarded for further work on sugarcane. The following varieties from the New Area nursery were, therefore, planted in the Botanical Area in February 1936 along with the standard varieties of sugarcane :—

Co. 210, Co. 213, Co. 281, Co. 299, Co. 313, Co. 331, Co. 344, Co. 347, Co. 348, Co. 366, Co. 368, Co. 369, Co. 370, Co. 371, Co. 374, Co. 375, Co. 377, Co. 378, Co. 381, Co. 382, Co. 384, Co. 386, Co. 391, Co. 394, Co. 412, Co. 413, Co. 417, Co. 419, Co. 420, Co. 421, Co. 422, Co. 423, Co. 424, Co. 425, Co. 426, Co. 427, Co. 428, Co. 429, Co. 430, Co. 431, Co. 432, Co. 433, Co. 434, Co. 500, Co. 501, Co. 502, Co. 503, Co. 504, Co. 505, Co. 506, Co. 507, Co. 508, Co. 509, Co. 510, Co. 511, Co. 512, Co. 513, Co. 514, Co. 515 and Co. 516.

The following varieties were received from Coimbatore during February and March 1936, and they were planted in Simri Dhab :— Co. 439, Co. 440, Co. 520, Co. 521, Co. 522, Co. 523, Co. 524, Co. 525, Co. 526, Co. 527, Co. 528, Co. 529, Co. 530, Co. 531, Co. 532, and Co. 533.

The results of chemical analyses of all varieties grown on a large scale are given in the table below.

Results of chemical analysis of principal sugarcane varieties during 1935-36

Sugarcane variety	Field	Sucrose per cent in juice				
		November 1935	December 1935	January 1936	February 1936	March 1936
I.—*Ratoon*—						
Co. 210	New Area	12·46	13·46	..	..	..
Co. 213	,,	10·61	13·64	..	..	..
Co. 214	,,	12·53	16·15	..	..	..
Co. 281	,,	11·65	13·79	..	..	..
Co. 299	,,	15·24	17·24	17·59	..	..
Co. 313	,,	14·42	15·31	..	..	..
Co. 331	Gonhri	..	10·28	..	..	..
II.—*Plant*—						
Co. 210	New Area	13·47	14·22	15·73	16·74	17·88
Co. 213	,,	9·21	14·79	16·36	14·50	18·45
Co. 214	,,	14·54	15·38	17·29	..	..
Co. 281	,,	16·06	17·14	17·05	18·93	19·46
Co. 299	New Area	15·98	18·36	18·47	18·81	..
	Harpur Jhilli	..	..	..	..	18·96
Co. 313	Old Jhilli	13·48	14·72	..	..	..
	Brickfield I	..	..	..	..	17·96
Co. 331	New Area	..	10·15	14·44	15·66	18·29
Co. 337	Brickfield I	14·20	15·28	15·93	..	..
Co. 339	,,	12·58	15·24	16·35	..	..
Co. 343	Harpur Jhilli	13·09	14·71	..	..	..
Co. 344	,,	13·90	14·49	..	..	..
Co. 387	,,	14·56	14·82	..	..	..
Co. 388	,,	13·25	14·78	..	..	..
Co. 393	,,	14·91	15·56	..	..	..
Co. 395	,,	12·53	15·19	..	..	..
Co. 396	,,	14·55	16·10	..	..	..
Co. 397	,,	15·71	15·61	..	..	..

VII. MACHINERY AND BUILDINGS

1. Steam Ploughing Tackle

The Fowler's Steam Ploughing Tackle which was transferred to Delhi at the end of the last year, though 23 years old, did excellent work throughout the year under report, with the Fowler's land levelling scoop, in laying out and levelling the agricultural land at the new Imperial Agricultural Research Institute.

2. Tractors

Vicker and Lanz Bulldog tractors were sent to Karnal to help *rabi* cultivation at the Agricultural Sub-station. The other tractors —Marshall and McCormick Deering—were not worked owing to curtailment of activities at Pusa and for the sake of economy in expenditure.

The Farmall 9/18 H. P. row crop tractor was used for the interculture of sugarcane and ridging it up before monsoon and worked satisfactorily. This tractor was fitted up with pneumatic tyres by the Goodyear Company of Calcutta for trial on road work. It has proved very satisfactory in pulling two 4-wheel trollies loaded with heavy packages, to Pusa Road Railway Station, a distance of six miles.

3. Pneumatic equipment for bullock carts

Twenty-four carts fitted with Dunlop tyres and tubes and two fitted with Goodyear tyres and tubes were used for cane carting throughout the entire cane season from 15th November 1935 to 11th April 1936. Out of 89,447¼ maunds of total cane, 46,092¾ maunds were carted direct to the Samastipur sugar mill (14 miles) and 43,354½ maunds to Pusa Road Station. All over, the average load per cart per trip was 48 maunds. The carts were loaded in the cane fields and were pulled through the cane stubbles, and all sets worked very satisfactorily except a little wear on two tyres and puncture in two tubes.

4. Design of Buildings

A complete set of farm and dairy buildings was designed and sited during the year under report and the plans handed to the Central Public Works Department for erection at the New Delhi Site.

VIII. CATTLE BREEDING

1. Pusa Pedigree Sahiwal Herd

As the year under report closes (June 30, 1936) the last year in which this herd will remain at Pusa, it will not be out of place to review rapidly the position it now occupies after 32 years at Pusa.

The cattle buildings and the grazing area were all part of the original Horse Breeding Stud Farm from 1796—1874.

The first proposition to use this area for a cattle-breeding and dairy farm was put forward in 1902.

The first lot of 14 Sahiwal cows and 1 bull arrived in 1904 and were augmented in 1907-08 by another of 26 cows, and this herd

formed the foundation of the present stock. The cattle were purchased from the Sahiwal (Montgomery) district in the Punjab, and one of the original ideas of establishing them at Pusa was to see if a desert breed could and would be successful if removed to a distinctly different set of climatic conditions. This fact has been clearly demonstrated, and the present herd is in every way the equal or superior of the cattle brought to Pusa originally. With this are given the comparative weights and measurements of the present herd compared to those of the original.

Average body weights of the Pusa Herd

Particulars	Weight		Differences
	Original herd	Present herd	
	lb.	lb.	lb.
Bulls	929	1,109	+180
Cows	704	802	+98
Heifers 3 years old	590*	765	+175
Heifers 2 years old	498·5	644	+145·5
Heifers 1 year old	278·5	459	+180·5

* Heavy in calf.

Measurements of the original and the present herds

Particulars of measurements	Old herd		Present herd					
	Soormi	Khoormi	Laruli	Lalagi	Mopati	Chakai	Atuly	Lakhni
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Height of hump	4 ½	3 11	4 ½	4 2	4 1½	4 1½	4 2½	4 4
Height behind hump	3 10½	3 10	3 11½	4 0	4 ½	3 11	4 0	4 1½
Girth	5 4½	5 1½	5 3½	5 6½	5 3	5 4	5 7½	5 11
Length from behind hump to point of pubis.	3 7	3 8½	4 0	3 10	3 8	3 9	3 9	3 11
Length of quarter	1 4½	1 5	1 4	1 5	1 3½	1 5	1 3½	1 5
Width of pelvis	1 4½	1 4½	1 5½	1 6	1 5	1 6	1 5½	1 7
Length of ears, outside curve.	0 10¾	0 10½	0 10½	0 10	0 9	0 9	0 9	0 10
Length of horns, outside curve.	0 9	0 9½	0 4	0 3	0 3	0 3	0 5	0 4
Circumference of horn at base.	0 7	0 6½	0 5½	0 5½	0 5	0 5½	0 5½	0 5½
Width of forehead (greatest convexity measuring from the base of each horn).	0 8	0 7	0 7½	0 8	0 8	0 6½	0 7½	0 8½
Length of face from poll to muzzle.	1 7½	1 7½	1 7	1 7½	1 6	1 7	1 7	1 7
Length of canon	0 7¼	0 7½	0 6½	0 6	0 6	0 6½	0 6½	0 7
Height at croup	4 1½	4 0	4 4½	4 2½	4 3½	4 1	4 3¾	4 4½
Girth of canon	0 6½	0 6¾	0 6¾	0 7¼	0 6½	0 6	0 6½	0 7½

The herd now moves to Delhi and re-enters its original habitat, a testimony to proper breeding, feeding and handling under different climatic conditions for 32 years.

Its health has been excellent, and the only contagious disease has been foot-and-mouth which has visited the herd yearly. The health standard is now so good that hardly any diminution of milk supply was noticed during the last outbreak.

2. Milk Yield

The average yield per cow per day for the year under report was 21·2 lb. as compared with 19·1 lb. for the previous year.

Statement of milk yield for the year 1935-36

Month	Total yield (excluding stripping)	Average yield		Number of cows			
		Per day	Per cow per day	Total	In milk	Dry	Percentage in milk
July 1935 .	17,678	570	19·0	55	30	25	54·5
August 1935 .	18,819	607	19·6	56	31	25	55·4
September 1935	21,335	711	20·3	56	35	21	62·5
October 1935	20,768	670	19·7	56	34	22	60·7
November 1935	15,098	503	19·3	50	26	24	52·0
December 1935	13,849	447	19·4	55	23	32	41·8
January 1936	15,274	493	21·4	57	23	34	40·3
February 1936	15,132	522	21·7	59	24	35	40·7
March 1936 .	22,325	720	24·0	58	30	28	51·7
April 1936 .	23,586	786	23·8	62	33	29	53·2
May 1936 .	23,636	762	23·1	65	33	32	50·8
June 1936 .	23,767	792	22·6	64	35	29	54·7
Average .	19,272	632	21·2	58	30	28	51·5
Average for 1934-35.	18,818	619	19·1	54	32	22	60·0

This result, which is such a marked improvement on previous years, has been attained by the exceptional producing power shown by all the heifers coming into milk, while the second calvers also showed an improvement on the average of past year.

Milk yield of heifers and second calvers

Year	Heifers		Second calvers	
	Number	Milk yield per cow per day	Number	Milk yield per cow per day
		(lb.)		(lb.)
1925-26	24	10·6	..	..
1926-27	38	9·1	..	..
1927-28	34	9·5	..	..
1928-29	24	11·5	..	..
1929-30	23	10·2	..	..
1930-31	27	8·9	..	..
1931-32	23	11·2	..	..
1932-33	32	13·2	..	..
1933-34	29	11·0	..	..
1934-35	34	15·0	5	21·1
1935-36	43	14·7	14	21·7

The special feeding and handling of this herd, which has now been in progress for almost five years, has shown marked results, and this management coupled with the breeding policy is now producing a constant stream of high class cattle.

A list of cows and heifers which completed their lactation in the year under report is given below. The number of cows over 9,000 lb. shows a steady increase, and the herd average is steadily moving up to 6,000 lb.

Some of the best cows and heifers that completed their lactation during the year 1935-36

Name and No.	Date of birth	No. of calvings	Milk yield	Days in milk
			(lb.)	
Cows				
Adami 503	25-5-24	6	9,357	306
Atuly 480	22-11-23	8	9,012	304
Ramati 566	19-3-27	5	9,272	305
Laruli 604	20-10-29	3	9,138	314
Amba 495	28-2-24	8	8,037	304
Chandarma 569	14-5-27	5	8,015	304
Heifers				
Chansuri 653	11-3-32	1	7,686	305
Birbutia 659	16-5-32	1	5,843	304
Bibsoorti 675	16-1-33	1	4,858	305
Chamati 662	1-6-32	1	4,580	305
Chaprama 676	4-2-33	1	4,306	304
Bubla 671	23-10-32	1	4,121	305

NOTE.—Cow Cellota milking only 3 quarters did 9,348 lb. in 305 days, but is not included in the above list.

3. Calf Rearing

The calf mortality figures for the year were 1·6 per cent as against 24·2 per cent last year when foot-and-mouth carried off 11 calves. This year all milk was boiled before feeding to calves, and the outbreak caused no casualties. An article on calf rearing has been submitted for publication.

Percentage of mortality amongst the pail-fed calves during 1935-36

Year	Births	Deaths	Mortality per cent	Remarks
1934-35 . . .	62	15	24·2	Including 11 calves died of foot-and-mouth.
1935-36 . . .	61	1	1·6	

4. Sale of Cattle

Drafting continued, and the herd is now up to a very close standard of performance and type.

Particulars	No. of animals	Total price	Average (Per head)	Average for 1934-35
		Rs.	Rs. as.	Rs. as.
Cows	9	1,150	127 12	159 9
Heifers	5	320	64 0	75 0
Young bulls	2	155	77 8	44 5
Steerlings	8	410	51 4	31 13
Cow-calf	1	Sold with her mother.		
Total .	25			

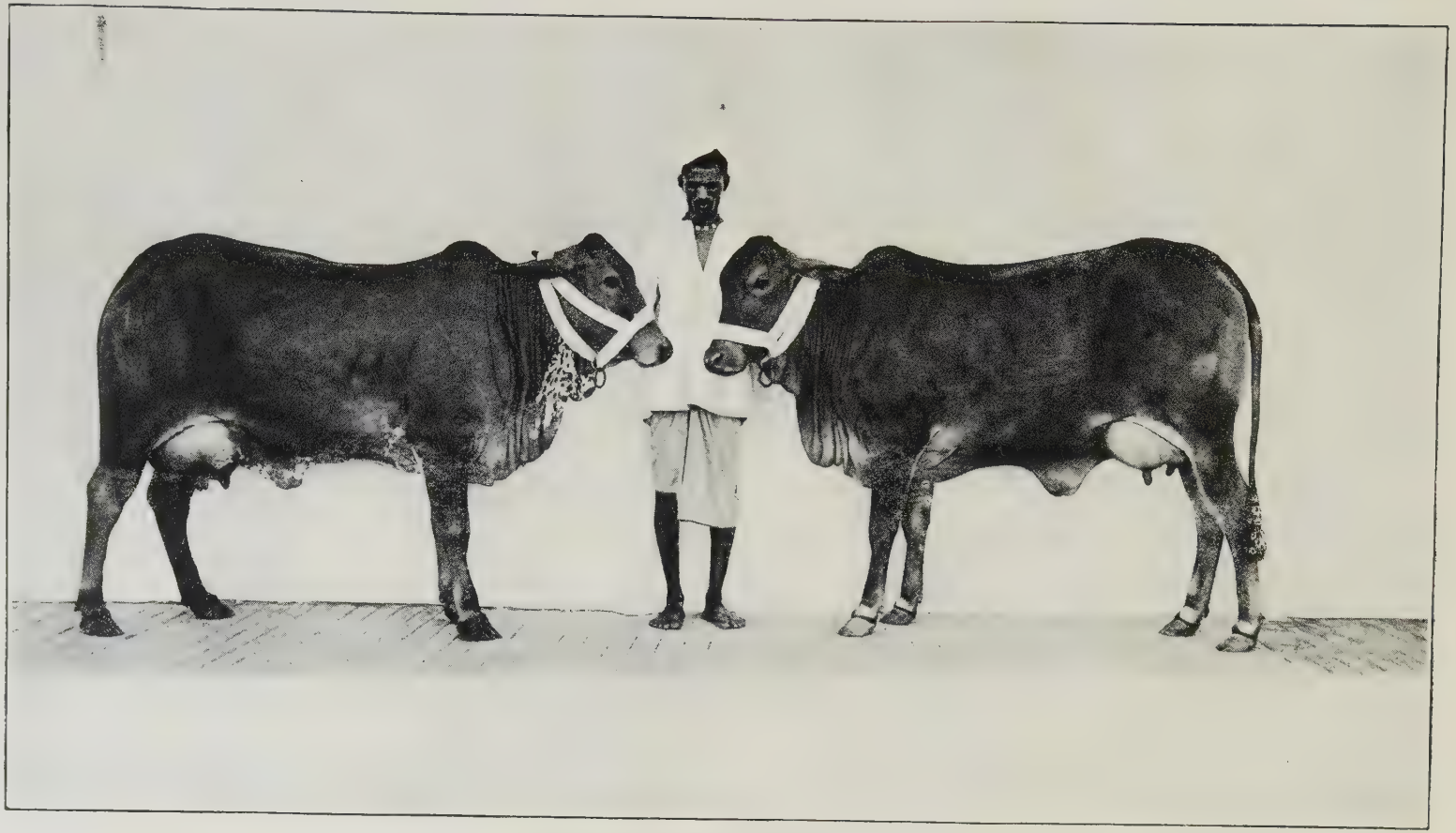
5. Early Maturity Experiments

The early maturity experiments were continued, and it may be noted here that the majority of the improvement recorded in the milk yield is attributable to early maturity heifers and second calvers, while, as shown above, the health and condition of the calves continues excellent. The fears of deterioration and lack of vigour do not yet seem to be justifying themselves.

Plate III is a photograph of two early maturity (18 months) heifers; both are giving over 20 lb. per day at 2 years and 3 months and, as can be seen, are fully developed in every way.

6. Rationing

Since the publication of the last report, the rationing of the entire herd has been re-balanced. It is still on the 3-1 basis, but a considerable addition has been made in the protein content by substitution of ingredients. Considerable assistance was obtained



EARLY MATURITY HEIFERS

1. Sahiwal cow Chakdari No. 708.
Date of 1st calving 15-5-36.
Age at 1st calving 2Y. 3M. 22D.
Total yield upto 30-6-36—1,105 lb. in 45 days.

2. Sahiwal cow Machrama No. 706.
Date of 1st calving 20-4-36.
Age at 1st calving 2Y. 3M. 27D.
Total yield upto 30-6-36—1,458 lb. in 69 days.

PLATE III.

from prominent English feeding authorities in this matter, and it is now seen that going back in heavy milkers is able to be checked at an early stage. The whole milch herd is also individually rationed, and it is evident that with our existing high average yields such attention is essential.

7. Training for cattle handling

The articles on handling and feeding already published having caused much interest and enquiry, it was found necessary to start a training class for cattle handling. Some twelve persons are now learning the rudimentary facts of how to handle cattle properly. Such training will make a considerable difference to the cattle work on outside farms.

The entire herd kept good condition throughout, except at the end of the year when a mild type of foot-and-mouth disease visited the herd and passed away without any mortality.

The herd is being inoculated with serum simultaneous goat virus before the journey to Delhi.

The first report on early maturity experiments, the third report on feeding and handling experiments, a note on handling and an article on calf rearing were sent for publication.

The History of the Pusa Herd is now in MSS.

The annual statement of live-stock is given in the table below.

Annual statement of live-stock as it stood on the 30th June 1936

Description of cattle	Number of animals from last year	Increase			Decrease			Total
		By birth	By transfer	By purchase	By death	By transfer	By sale	
Bulls for breeding	14	...	6	...	...	1	...	19
Bulls at New Area	1	...	1	...	...	2	...	...
Cows—Milch herd	55	...	28	1	...	18	2	64
Cows for breeding	3	...	...	...	...	...	...	3
Cows for sale	1	...	10	...	...	...	6	5
Cows—old	1	...	...	...	1	...	...	...
Cows at New Area	1	...	8	...	5	...	1	3
Young male stock in Dairy.	27	29	...	...	1	16	10	29
Young male stock for sale.	...	...	12	...	...	...	...	12
Young male stock at New Area.	...	1	...	...	...	...	...	1
Young female stock in Dairy.	74	28	...	...	3	32	6	61
Young female stock for sale.	...	...	2	...	...	...	...	2
Young female stock at New Area.	...	1	2	...	1	...	...	2
Bullocks	2	...	...	...	...	...	...	2
Total	179	59	69	1	11	69	25	203

IX. PUBLICATIONS

The undermentioned papers were published during the year under report :—

1. Sayer, Wynne . Fodder and forage crops at Pusa. *Herbage Reviews.* Imp. Bureau of Plant Genetics. **3**, 1935, 152-158.
2. ———— . Handling of the Pusa Pedigree Sahiwal herd. *Agri. & Live-stock in India*, **6**, 1936.
3. ————, Vaidyanathan, M., & Subramonia Iyer, S. . Ideal size and shape of sugarcane experimental plots based upon tonnage experiments with Co. 205 and Co. 213 conducted at Pusa. *Ind. Jour. of Agri. Sci.*, **6**, 1936.

X. PROGRAMME OF WORK FOR 1936-37

1. Continuation of the permanent manurial and the new manurial rotation experiments in the Punjab field.
2. Isolation of pure types of cowpeas.
3. Study of the new varieties of sugarcane received from Coimbatore.
4. Special feeding of the young stock with a view to early maturity in the Sahiwal breed.
5. Investigations on resistance of soil to bullock drawn implements.
6. Continuation and collection of data and results regarding the cost and capabilities of the steam ploughing tackle.
7. Investigation on the threshing problem in India.
8. Training of post-graduate students.

2. AGRICULTURAL SUB-STATION, KARNAL

I. CHARGE

I took over charge of the Imperial Cattle Breeding Farm, Karnal, on the 1st January 1936 from the Imperial Dairy Expert. This will in future be a sub-station of the Imperial Agricultural Research Institute and will deal in mixed farming.

Mr. Lamb, Superintendent, was in actual charge until the 29th February 1936, when he proceeded on leave preparatory to retirement. Mr. S. M. Jamaluddin, Second Cattle Superintendent at Pusa, was appointed to officiate in his place.

II. CATTLE HERDS

The Farm holds two pedigree herds—Thar Parkar and Hariana—which constitute the cattle-breeding side of its activities.

The few buffaloes previously maintained have been marked for drafting to Bangalore and outside buyers, as it is not intended to continue buffalo-breeding on this farm.

The Hariana and Thar Parkar herds have been thoroughly examined and classed, and certain animals marked for immediate drafting.

I have immediately made necessary alterations in the breeding and housing arrangements of these two pedigree herds in accordance with those which have given such good results at Pusa.

Both herds are being drafted into families and headed by selected bulls, all selections being based on type and pedigree.

All cows and heifers are being handled and milked before calving and are settling well to this new treatment: to-date out of 24 cows and heifers handled, only one has failed to respond, and a marked increase has already been shown in the yield. No difficulty has been found in getting the staff to carry out this work, and they are now doing it most efficiently.

The system of calf rearing has been entirely altered. The ration has been brought up to the Pusa standard and all calves handled separately. The results to-date are most encouraging. The actual calf mortality for the year was 22·2 per cent or 33 deaths on the farm out of 144 births.

All animals up to one year old are now weighed and weights recorded each week.

Progress boards on the Pusa standard for Thar Parkars and Harianas have been started, and special heifer boards for each breed. All the cows have been re-named, and the entire stock branded in the Pusa fashion.

The buildings, yards, fencing and cattle steadings are too old to be useful and require to be demolished and re-built at the earliest

opportunity, and steps have been taken to draw immediate attention to this fact for the next budget.

The policy of feeding the herd as far as possible off the land has been introduced.

III. CULTIVATION

The cultivated area of the Farm worked by the farm staff was about 173 acres in all, and from the 1st April 1936, a further 294·39 acres, which had been under the Pusa agricultural staff, was brought in together with 86·71 acres till then under the Botanical Substation for seed multiplication. Plot No. 6 of 180 acres lately under *batai* has now been taken over, and 200 acres in Nos. 2 & 3 have been brought under direct cultivation.

Plot No. 7 of 400 acres is to remain under *batai* for the present until it can be taken over.

The yields of crops in *rabi* were as follows :—

Crop	Area	Total yield	Average yield per acre
	(Acre)	(Mds.)*	(Mds.)*
Oats B. S. I.	126·96	2,629·80	20·79
Oats H. J.	191·25	3,127·80	16·35
Barley	29·10	304·00	10·45
Gram	104·89	1,490·10	14·20
Green berseem	1·18	224·19	189·99
Green oats	0·95	514·50	541·58

* 1 maund = 82·28 lb.

The whole of the existing farm machinery calls for reconditioning and supplementing by modern outfits. As a preliminary step, two new W. D. 40 McCormick Deering Diesel tractors have recently been purchased with a 9 ft. harrow plough and 12 ft. cultivator. Many more bullock and power implements are needed to deal with the increased area taken under direct cultivation this season.

The whole agricultural area will have to be relaid out with an economic irrigation design, supplemented by tube wells, and an efficient system of drainage, to permit the station to function efficiently as a mixed farm with an experimental branch.

3. STATISTICAL BRANCH

(P. V. Krishna Iyer, M.A.)

I. STATISTICAL WORK

Advice and assistance were rendered to all the Sections of the Institute and outsiders on various occasions, and the following detailed statistical analyses were carried out:—

(*i*) The tonnage loss caused by sugarcane borers in fields of Co. 331 and Co. 214 was worked out on the basis of data collected by the Imperial Entomologist in February and March 1935. The total loss due to borers in a crop of Co. 331 was found to be 6·25 per cent, while in Co. 214 this loss was *nil* as disclosed by the data. It may be mentioned that the soils in which the two varieties were grown were different: Co. 331 was grown in the Gonhri field possessing heavy soil, whereas Co. 214 was grown in the North Pangarbi where the soil is decidedly light in texture. The main results of the analysis are given in the Report of the Imperial Entomologist.

(*ii*) The relation between the virulence of wilt in artificially infected *rahar* plots as judged from the percentage deaths at any stage and the natural factors of rainfall, soil temperature and age was worked out for the Botanical Section and it led to the following conclusions:—

(*a*) In the initial stages the plants are more susceptible to the attack of wilt.

(*b*) Deaths are increased by heavy rainfall and fall in soil temperature.

II. RESEARCH WORK

1. Soil heterogeneity judged from mechanical and chemical analyses

The results of the chemical and mechanical analyses of a series of samples of surface and sub-soils taken from two fields A_1 and A_2 were carefully analysed, and the findings of the statistical analysis are set forth in the succeeding paragraphs.

(*i*) As would be expected, the divergent nature of the two fields was most evident. Comparing A_1 and A_2, the surface soil of A_2 contained more of CaO and MgO, whereas the sub-soil of A_1 was richer in T. K_2O, MgO and moisture. Field A_1 contained more of fine gravel, coarse sand and less of fine sand and fine silt. Both A_1 and A_2 had more of K_2O and available P_2O_5 in the surface soil than in the

sub-soil. The variation within the sub-soil samples was far more than among the surface soil samples.

(*ii*) Correlation between samples taken at different distances was worked out and it was found that as the distance increased the value of the correlation decreased. High correlation existed in samples of soils spaced by about fifty feet. The correlation beyond this distance was seen to be insignificant in many cases. These facts were corroborated by the intra-class correlation values also.

(*iii*) In the case of 'Randomized Block' lay-outs it can be established that the elimination for soil heterogeneity will be most effective provided the blocks are selected in such a way that the variation within it is minimum. The coefficient of variation within blocks of 2/20 acre, 4/20 acre, 6/20 acre, 8/20 acre, 9/20 acre and 10/20 acre was worked out on the basis of 2, 4, 6, 8, 9, and 10 samples respectively from each block. The variation in 4/20 acre blocks was found to be practically minimum. It was far less than that of the whole field and almost equal to the 2/20 acre blocks. But as the size was further increased the variation rapidly approached the value for the whole field. On the whole, for fields of 20 per cent or 25 per cent variation 1/5 acre blocks appeared to be the best for 'Randomized Block' lay-outs.

2. Milk yield—Sahiwal herd

(*i*) The succeeding table gives the average milk yield of the Sahiwal herd at Pusa for different lactations during the periods 1904-1913, 1914-1923 and 1924-1934.

Average milk yield for different lactations

No. of lactation	Milk yield	Size of sample	Remarks
	lb.		
	Group I	*(1904-1913)*	
1st	3,328	38	Standard deviation = 1042·00 lb.
2nd	3,353	46	Both the 'z' and 't' tests do
3rd	3,374	40	not show any significant in-
4th	3,490	29	crease in milk yield as the age
5th	3,236	24	increases.
6th	3,616	24	
7th	3,038	13	
8th	3,520	9	
9th	2,752	8	
10th	3,389	1	

No. of lactation	Milk yield	Size of sample	Remarks
	Group II (1914-1923)		
1st	3,347	101	'z' test shows significance. Standard deviation = 961·99 lb. Differences between the means are significant in many cases. Effect of age on milk yield is clearly brought out here.
2nd	3,607	84	
3rd	3,652	78	
4th	3,750	67	
5th	3,773	41	
6th	3,044	26	
7th	3,159	16	
8th	3,385	7	
9th	2,972	3	
10th	1,421	2	
	Group III (1924-1934)		
1st	3,265	52	'z' test shows significance. Standard deviation = 1,150·5. Some of the differences between the means are significant. The effect of age is clear here also.
2nd	3,891	40	
3rd	4,251	32	
4th	4,340	27	
5th	4,460	24	
6th	3,901	19	
7th	4,498	14	
8th	4,411	7	
9th	4,308	3	
10th	3,983	2	

It will be seen from the above tables that Group I cows do not lead to any definite and tangible results. This is due to the fact that proper records are not available for that period. The average milk yields of Group II and III cows clearly show that the yield remains stationary during the 3rd, 4th and 5th lactations and afterwards it shows a fall. The superiority of the cows of the last decade is also brought out by the same table.

A study of the milk yield of cows, lactation by lactation, has shown that the influence of season of calving on milk yield is negligible so far as Pusa is concerned. An examination of a number of calvers in different months indicates that more calvings take place in the months of December and January and less in the months of August, September, October and November, from which it can be inferred that the reproductive force is maximum in the months of February and March and minimum in the months of September, October and November.

3. Investigations for simplifying the lay-outs of 'Confounded Experiments'

Yates has shown how reductions in the number of replications for field experimental purposes can be effected without seriously affecting the efficiency of the experiment by confounding the second order interactions with sub-block differences. By sacrificing information about the second order interactions which are not of much

importance we are able (1) to reduce the number of replications and (2) to get an effective elimination of the error due to soil heterogeneity. With a view to simplify the laying out of ' Confounded Experiments ', methods which will facilitate the lay-out and analysis of such experiments were devised for the calculation of the second order interactions.

4. Yields of missing plots

A new method has been devised for the estimation of variance due to residual error when plot yields are missing from experimental areas. The method consists in evaluating the actual value of the random errors for the various plots under certain assumptions.

III. PUBLICATIONS

Krishna Iyer, P. V. . A statistical study of the body weight figures of special and ordinary fed calves at Pusa. *Ind. Jour. Vet. Sci. and Ani. Hus.*, **5**, 251-265 (1935).

Papers submitted for publication

Sayer, Wynne, and Krishna Iyer, P.V. — A note on replications in field trials.

Krishna Iyer, P. V. . On the assumptions involved in the statistical analysis of ' Randomized Block ' and ' Latin Square ' lay-outs and its applicability in the estimation of yield of missing plots.

——————— . Methods for the estimation of interactions and its utility in laying outs ' Confounded Experiments '.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(B. P. Pal, M.Sc., Ph.D., F.L.S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. F. J. F. Shaw, C.I.E., held charge of the Section until the fore-noon of the 26th October 1935, when he was appointed to officiate as Agricultural Expert to the Imperial Council of Agricultural Research. Dr. B. P. Pal, Second Economic Botanist, was appointed to hold charge of the office, in addition to his own duties, from the same date.

Mr. Kashi Ram, Assistant Economic Botanist, remained throughout the year on special duty as head of the lay-out party at the new site of the Institute in Delhi.

The Botanical Sub-Station, Karnal, was formally transferred to Pusa on the 15th May 1936, when Mr. R. D. Bose was appointed as Superintendent, *vice* Mr. Hukam Singh who was reverted to his substantive post of Assistant. Mr. R. B. Deshpande took charge of the duties of the Special Research Assistant from Mr. Bose on the same day.

Receipts.—A sum of Rs. 2,855/9/3 (two thousand eight hundred and fifty-five, annas nine and pies three only) was realized from the sale of improved seeds, etc., during the financial year ending 31st March 1936, and was credited to Government.

Training

Post-graduate training.—Messrs. P. Krishna Rao, S. Z. Hasanain, A. K. Paul and S. B. Vaidya completed their post-graduate training during the year and were of material help in the investigations with which they were concerned. Messrs. R. K. Tandon, A. K. Mallik and S. D. Misra continued to receive training.

Messrs. N. Alam (Punjab), C. A. Joseph (Travancore), S. Sen (Bengal) and G. Ranganathaswami (Madras) were admitted this year.

Students from the Agricultural, Chemical, Entomological and Mycological Sections also attended the course of lectures delivered in this Section on Biometry and Field Statistics. A Dairy Course student spent a week in the Section.

Short Course in Flue-curing of Tobacco.—The following students were given a special two months' course which consisted of lectures as well as practical training in flue-curing of tobacco :—

1. Mr. A. P. Mishra . (Bihar).
2. Mr. Obeidullah Jan . (North-West Frontier Province).
3. Mr. Indrapal Singh . } (Gwalior State).
4. Mr. Prithvi Singh . }
5. Mr. D. N. Kachru . (Kashmir State).

The first two students were deputed by Provincial Agricultural Departments and the remaining three by States.

Season and Rainfall

The total annual rainfall remained below the average for the last 30 years (1906—1935) by 2·58 inches. There was an appreciable excess in September and a deficiency in July. The winter rains were deficient with the result that yields of most of the crops were affected.

Heavy incidence of rust on wheats, barleys, linseeds, etc., was a feature, and with the deficiency of winter rains, responsible for reduced yields and the poor quality of grain in some crops.

A statement of rainfall in the Botanical Section during the year is given below :—

Statement of rainfall in the Botanical Section in 1935-36

Month	Average for 30 years 1906—35	From 1st June 1935 to 31st May 1936	Difference
	Inches	Inches	Inches
June 1935	7·33	7·54	+0·21
July	11·64	4·69	—6·95
August	13·15	11·20	—1·95
September	8·09	16·23	+8·14
October	1·79	0·38	—1·41
November	0·47	0	—0·47
December	0·16	0	—0·16
January 1936	0·36	0·05	—0·31
February	0·66	0·13	—0·53
March	0·35	0·25	—0·10
April	0·51	0·26	—0·25
May	1·41	2·61	+1·20
Total .	45·92	43·34	—2·58

Statement showing the seed distribution in 1935-36 of improved varieties of crops evolved in the Botanical Section, Pusa

Crop	Quantity in lb.	Remarks
	lb. oz.	
Barley Types		
Type 1	1	
,, 13	16 0	
,, 16	16 0	
,, 18	16 0	
,, 21	3,373 7	
Hybrid H-300A	1 0	
,, H-160-2	1 0	
,, H-2-265	1 0	
Chillies Types		
Type 34	2 8	
,, 41	2 4	
,, 46	0 8	
,, 51	1 8	
Flax seed		
J. W. S.	8 0	
Gram Types		
Type 2	78 3	
,, 6	72 0	
,, 17	822 14	
,, 25	987 6	
,, 28	164 0	
,, 53	41 0	
,, 55	8 0	
,, 58	452 10	
Ganja seed		
Mixed	61 9	
Linseed Types		
Type 12	113 4	
,, 121	131 10	
,, 124	207 12	
Hybrid 10	24 0	
,, 21	10 0	
,, 55	16 0	
,, 65	2 0	
,, 69	2 0	
,, 68	20 0	
,, 70	1 0	
Lentils Types		
Type 11	10 0	
,, 47	6 0	
,, III-86	265 6	
Mung Types		
Type 18	28 0	
,, 23	18 0	
,, 28	37 0	
,, 33	2 0	
,, 36	23 0	
Oats		
B. S. 1	415 0	
B. S. 2	102 0	
Hybrid C	1,038 14	
Hybrid G	172 12	
,, J	226 4	
,, 7-54	1 0	
Patwa Types		
Type 3	53 8	
,, 6	14 0	
New Patwa	87 4	
Paddy Types		
Type 9	30 14	
,, 18	257 2	
,, 24	401 2	
,, 31	594 8	
,, 52	187 2	
Peas Type		
Type 29	181 0	
Potato Varieties		
Pusa local variety	82 0	
Rahar Types		
Type 4	2 0	
,, 24	17 0	
,, 51	415 8	
,, 80	189 4	
,, 72	2 0	
Hybrid 38	205 9	
Safflower Type		
Type 1	5 0	
,, 6	1 0	
,, 7	1 0	
,, 30	43 0	
Sesamum Types		
Type 3	3 2	
,, 7	6 0	
,, 29	3 0	
Tobacco Types		
Type 18 (*N. rustica*)	7 12	
,, 28	7 8	
,, 63	0 10	
Hybrid 142	8 8	
,, 177	2 2	
Adcock	4 8	
Harrison's Special	4 8	
Wheat Types		
Pusa 4	421 10	
,, 12	49 0	
,, 52	4,525 10	
,, 80-5	205 9	
,, 111	195 6	
,, 114	78 2	
,, 120	55 8	
,, 165	67 14	

II. INVESTIGATIONS

Wheat (*Triticum vulgare* Host.)

The prolonged drought referred to in the preceding section adversely affected the crop, and both yields and bushel weights were well below the average. The best outturn was given by Pusa 52 which grown on an area of 0·2 acre yielded at the rate of 1,512 lb. of grain per acre; Pusa 80-5 showed the highest bushel weight. The bushel weights are given in Table I.

TABLE I

Bushel weights of some Pusa wheats

Variety	Weight per bushel in lb.		
	Average for the six years ending 1933-34	1934-35	1935-36
Pusa 4	64·42	64·90	63·16
Pusa 12	62·39	62·60	54·52
Pusa 52	65·31	65·31	63·92
Pusa 80-5	..	64·50	64·85
Pusa 101	..	65·95	62·02
Pusa 111	..	63·50	63·38
Pusa 114	..	..	63·62
Pusa 120	..	..	61·72
Pusa 165	..	..	61·79

The demand for seed as usual exceeded the available supply. For Pusa 4 alone, indents totalling 103,731 lb. were received. This wheat is particularly popular in the Bombay Presidency and the Deccan. In the Jullundur Circle of the Punjab there is a growing demand for seed of Pusa 80-5.

The yield trials of Pusa 120 and Pusa 165 at a number of farms in the United Provinces and the Punjab were continued. The results for the year under report are not yet available, but those for the previous two years have indicated that Pusa 165 is one of the best-yielding Pusa wheats. Pusa 120 tends to shed its grain when ripe but it has been found, in glasshouse tests by Dr. K. C. Mehta of Agra, to be very highly resistant to all the three physiologic races of yellow rust so far recorded in India. It should prove of much value as a parent for breeding rust-resistant wheats.

Hybrid vigour was studied in a cross between Pusa 52 and Pusa 165 wheats. A few striped plants found in the field were also under observation.

The wheat-breeding work carried out at the sub-station at Simla is described in the report of the Second Economic Botanist.

BARLEY (*Hordeum* spp.)

Genetical studies with Pusa barleys were continued, and the mode of inheritance of a number of qualitative and quantitative characters in specific crosses between *Hordeum vulgare* L. and *H. distichon* L. was investigated.

The progeny of a natural cross, observed two years ago in a segregating family of Nepal hooded barley × Pusa Type 21, was again raised this year. In addition to the segregation for hooded and awned condition, narrow and broad outer glumes and 6-rowed

and 2-rowed types of ear were also found to segregate on simple Mendelian ratios. As the original parents did not possess any genes for broad outer glumes and for two rowed condition, it seems that one of the hybrid plants was naturally cross-fertilised with pollen grains from an adjoining row of Type 1 barley which possesses these characteristics.

A recessive culture with virescent leaves has been isolated from the progeny of a stray plant collected two years ago in Pusa Type 21 barley. The nature of inheritance of plants with striped leaves in Type 21 is also under study. The vernalization experiment with barley and oats was continued again this year.

As reported last year, eight types of Pusa barleys were again sent for a malting test to the Institute of Brewing, London, through the Director of Agriculture, Bihar and Orissa. These samples were sent in two sets. One set was supplied from Calcutta and the other from Karachi in order to ascertain whether the longer and more humid voyage from the former port had any effect on quality. A report of the Institute of Brewing on the barleys submitted in 1934 has been received, and it is shown that the set shipped through Karachi contained about $1\frac{1}{2}$ per cent more moisture than that sent *via* Calcutta. In other respects the results of the analyses of both sets of barleys are similar. Samples of Pusa Type 21 grown in different districts of Bihar were distinctly different in respect of malting value. For instance, a sample of this barley grown at Patna was reported to be "a good, mellow, thin skinned barley—better than Indian barleys commercially imported in recent years," whereas the same barley sent from Sepaya was said to be " a well developed but very ugly barley.....which would be rejected on appearance, though suitable for distilling according to analyses ". Similarly the sample of Type 21 sent from Pusa was reported to be a " barley of common type and cannot be recommended".

Due to the incidence of heavy rust in some of the Pusa barleys during the present year it has been decided not to send any samples from this harvest to the United Kingdom for malting tests.

A number of Pusa hybrid barleys was supplied to the Department of Agriculture, Victoria (Australia), in 1934 and one particular hybrid, *viz.*, C. 8-119-23, F_4, has been reported by the Director of that Department to be outstanding on account of its early maturity and has been used there for hybridizing with some Australian varieties. Pusa barley Types 12 and 20 which were supplied to the same Department in 1931 have also been reported to have been extensively used for the breeding of early maturing forms.

Oats (*Avena sterilis* L. var. *culta* and *avena* sp.)

A new cross, Orion × Hybrid J, was studied in the F_2 generation. Orion is a late-maturing Swedish variety which produces a profusion of large, lush leaves. Were it not that its extreme lateness

renders it unsuitable for cultivation in most parts of Northern India, this exotic oat would be an ideal variety for green fodder. With the object of combining the good fodder properties of this variety with early or medium maturity of Pusa oats it was crossed with Pusa Hybrid J and a number of promising F_2 plants have been selected.

The studies on the inheritance of a number of characters in oats were continued.

In order to study the varietal resistance of Pusa and other, exotic, oats to a Pusa strain of covered smut, artificially infected seeds were sown in the Botanical Section, and a small part of the same seed was planted in the pot-culture house of the Mycological Section. The germination of the former was very defective possibly because of lack of sufficient soil moisture, and the experiment had to be abandoned for this season.

The seeds sown in the Mycological Section, however, germinated satisfactorily, and some data have been obtained on the comparative resistance of the varieties tested. It is proposed to continue this study.

Paddy (*Oryza sativa* L.)

The growth in the nurseries was poor because of the severe drought. This, combined with floods in August, was responsible for the low yields obtained in most cases. Owing to the very abnormal growth conditions, which affected some varieties very much more than others, the late paddies yield trial which had been laid down was abandoned. In the early paddies yield trial, however, growth was quite good. Here T. 125 (selected at Karnal) stood first, and T. 18 was second, in order of yield of grain.

The study of tillering in two strains of paddy was continued. The data from this have not yet been analysed.

Observations on chlorophyll deficient plants were continued and a few crosses between chlorophyll deficient and normal green plants were attempted.

Maize (*Zea Mays* L.)

Forty-four cultures, some selected for yield of grain, some for fodder and the others for both grain and fodder, together with inbred strains and their hybrids, were grown this year. The selfed ears from these cultures have revealed a gamut of endosperm colours, *viz.*, orange, light orange, yellow, lemon, dirty white, pearly and chalky white, and aleurone colours, *viz.*, red, purple and deep purple. Nineteen stocks segregated for defective endosperm characters.

Two mutant types, one liguleless and the other having salmon-coloured silks, were collected from a field of maize grown for fodder.

About ten plants from each of the forty cultures were artificially self-pollinated for breeding work. The inbred strains were further inbred and, for the purpose of ascertaining those that combine well, direct and reciprocal crosses between all the different strains were made.

Pigeon-Pea (*Cajanus indicus* Spreng.)

A large F_3 population of the cross T. 80 × T. 66 was studied this year in order to confirm previous observations on the mode of inheritance of the colour in leaf-vein, flower, pod, and seed. Whereas the inheritance of the first three characters is on a monogenic basis and they are perfectly linked with each other, the segregation for seed-colour appears to depend on the interaction of three factors and is quite independent of those for the other characters studied.

That the infestation of Fusarium wilt in a susceptible type of pigeon-pea was retarded by the toxic effects of tobacco stumps buried in the soil was reported last year and is again indicated by the results obtained this year.

In 1934-35 a pigeon-pea plant with streaked pods was found in a segregating family of T. 66 × T. 5 to possess two small branches in which the pods had non-streaked, green pods like those in the recessive parent. Seeds from different branches of this plant were sown this year and it was observed that all plants raised from seed of these two branches bore green-coloured pods, whereas most of the plants raised from the seed of branches with the normal streaked pods showed streaked condition of the pods while a very few plants from this series again showed most branches with streaked and some branches with non-streaked green pods. This may therefore be taken to be a case of somatic segregation and is probably the first case of its kind recorded in pigeon-peas.

Seed of the more promising wilt resistant hybrids (T. 80 × T. 5) has been multiplied this year with a view to commencing yield trials of these types against some of the standard Pusa varieties.

Gram (*Cicer arietinum* L.)

Seed of the types usually given out for distribution was multiplied. Slight damage was done to the crops by cut-worms (*Agrotis*) in December but the pest was controlled by hand picking.

Lentils (*Ervum lens* L.)

The yield trial of six hybrid lentils against two high yielding types was conducted for the third time this year. The results have not yet been fully analysed but like the case in previous years Type 11 has yielded very low this year, perhaps because of the continuous drought during the growing season.

Peas (*Pisum sativum* L. and *P. arvense* L.)

An yield trial was laid out with two types of *P. arvense* and three of *P. sativum*, S. 29 of the latter species being the control. The differences between yields of any two varieties were not found statistically significant.

Urid and *Mung* (*Phaseolus Mungo* L. var. *Roxburghii* and *Phaseolus radiatus* L.)

The study of the inheritance of some characters in a cross between a green-seeded (Type 18) and a yellow-seeded (Type 36) strain of Pusa *mung* has been completed and the results prepared for publication. Type 18 possesses a light yellowish olive-coloured flower and dark green pods with red veins on the sutures. Type 36 on the other hand has olive yellow flowers and green pods with no red colour on the sutures. This colour of the unripe pods has been found to be completely linked with the colour of the flower and a single factor difference has been observed for these characters.

The seed of Type 18 *mung* is of a dark green colour with a dull surface, while that of Type 36 is of a pale lemon yellow colour with a shining, glabrous surface. The inheritance of the seed-coat-colour depends on the interaction of two genes and is independent of the genes for dull and shining surface. The latter shows a clear-cut monogenic segregation. The inheritance of quantitative characters such as maturity and the size of pods has also been studied.

Yield trials with promising strains of *mung* and *urid* were in progress.

Sann-hemp (*Crotalaria juncea* L.)

A number of strains of sann-hemp has been selected, and the seed of these will be multiplied for further trials. The study of the root-system of sann-hemp was completed. The virus disease which was observed on this crop last year reappeared and was responsible for the decreased production of seed. Seedlings of sann-hemp sown late in August were damaged severely by *Colletotrichum*.

A complex yield trial experiment with one Pusa and four Bengal varieties of sann-hemp was laid out in randomized blocks with four different seed-rates and with four different dates of sowings (at fortnightly intervals). Retting was done at the correct stage of the plants' development and the yield of the retted fibre was taken as the criterion for comparison. This experiment will be repeated for at least two more seasons and is expected to furnish useful information regarding the best varieties, the correct seed-rate and the most suitable time of sowing the crop for fibre purposes. The seeds of the Bengal varieties of sann-hemp were kindly supplied by the Assistant Fibre Expert, Bengal, who also helped to evaluate the fibre obtained from the experimental plots.

Indian Hemp (*Cannabis sativa* L.)

Cured product (*ganja*) weighing 2 maunds and nearly 7 seers was obtained from a half-acre plot and sold to the Excise Department at the rate of Rs. 160 per maund. Thirty three seers of seed was also obtained from the same field.

Samples of *ganja* were kindly analysed by the Imperial Agricultural Chemist, Pusa, who obtained the following results using the carbon tetrachloride extraction method :—

Laboratory No. of 1936	Particulars of the sample	% Resin on sample	Specific rotation	% Ash on sample
162 . .	Pusa Ganja, mixed .	12·40	—112·1	17·54
163 . . .	,, ,, Type 1.	11·87	—117·9	17·58
164 . . .	,, ,, Type 2.	12·00	—115·8	16·87

Tobacco (*Nicotiana Tabacum* L. and *N. rustica* L.)

The study of tobacco leaf-curl was continued in collaboration with the Entomological Section. Five types of leaf-curl have been provisionally distinguished and experiments on these are in progress. The incidence of this group of diseases was also studied, and weekly counts of diseased plants were taken from the time of transplanting up to harvest. The data indicate that a certain amount of new infection takes place throughout the season but it is highest just after the seedlings are planted out.

The study of the cross between *N. Tabacum* and *N. plumbaginifolia* was completed. The hybrids were completely sterile and showed a number of features, *e.g.*, striping and streaking of flowers, not found in either of the plants. This is the first time that plants from this difficult cross have been successfully raised to maturity.

Potato (*Solanum tuberosum* L.)

The study of material collected from different parts of India and from abroad was continued. The major portion of the work on this crop was done at the sub-station at Simla where conditions are more suitable both for growth and for storage. A detailed account of the year's work will be found in the report of the Second Economic Botanist on the Potato Breeding Scheme.

Chilli (*Capsicum annuum* L. and *C. frutescens* L.)

A natural cross with *C. annuum* was observed in a culture (Type 2) of *C. frutescens*. The plant was very vigorous and showed dominance of green flower colour over white, pendent fruit position over erect, green colour of unripe fruit over cream colour and clustered pedicels over solitary ones. The progeny of the plant will be studied next year.

Hibiscus (*Hibiscus sabdariffa* L. and *H. cannabinus* L.)

The F_2 generation of the cross between yellow and white flowered varieties was studied and a ratio of 3 yellow-flowered plants to 1 white-flowered was obtained, indicating simple monofactorial segregation. As both the parent varieties are very early, an attempt was made to grow and study the F_3 generation also in the same season. The F_3 plants, however, did not thrive and the sowing will be repeated next year.

Linseed (*Linum usitatissimum* L.)

The objects of the experiment and the methods used in the breeding out of the flower colour factors have been described in the previous reports. Of the 200 F_2 plants from the phenotype with white petals and white anthers which were crossed with four different types of plants of known genetic constitution, only the progenies of 82 plants possessing yellow or grey seeds were grown. An analysis of the segregation indicated that, whereas about five plants lacked the flower colour factors B, D and F, it is doubtful whether the fourth colour factor, C, has been eliminated.

The F_1 of the cross between the yellow-tipped mutant found in Type 12 and Type 12 itself was normal green, showing that the normal green condition is dominant.

The study of the crosses between rust-resistant and rust-susceptible varieties was continued and was facilitated by the heavy incidence of rust.

Seven hybrids were compared for yield with Type 12 in a latin square lay-out. Type 12 proved to be a significantly higher yielder than the hybrids; the differences between the latter themselves were not significant.

Hybrid 68 which is very early and has bold seeds with a high oil-content was favourably reported upon by the Burma and Sind Departments of Agriculture.

Safflower (*Carthamus tinctorius* L.)

The F_3 families of a number of crosses were grown. Germination, however, was poor because of deficient soil moisture, and in many families enough plants were not available for a proper study. Seeds of these families will be grown again next year.

The F_2 of the cross between the chlorotic mutant and T. 27, which is normal green, showed segregation in the ratio of 3 normal green : 1 chlorotic.

Sesamum (*Sesamum indicum* DC.)

Continuous rain in August prevented sowing at the normal time, and the seeds were sown about a month later than the usual

sowing time. A number of strains obtained from the Punjab and Burma were grown for the first time. The detailed study of these with the object of discovering strains suitable for breeding purposes will be continued.

The F_1 generation of certain crosses was sown to see whether there is any hybrid vigour in this crop.

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1935-36

Crop	Plot	Area in acres	Out-turn of grain in lb.		Remarks
			Actual	Per acre	
Wheat—					
Pusa 4 .	Lawn plot 1 part	0·50	565·7	1,131·4	
,, 52 .	Inside Musahar 1	0·82	1,028·6	1,254·4	
,, 52 .	,, ,, 3	0·33	397·0	1,203·0	
,, 52 .	,, ,, 4	0·66	748·8	1,134·5	
,, 52 .	Outside ,, 4	0·20	121·4	607·0	on alkali land
,, 52 .	,, ,, 5	0·20	302·4	1,512·0	
,, 80-5	Barah 1 part .	0·50	613·0	1,226·0	
,, 101 .	,, 2 ,, .	0·50	390·9	781·8	on alkali land
,, 111 .	,, 1 ,, .	0·50	475·2	950·4	
,, 114 .	,, 1 ,, .	0·38	489·6	1,288·4	
,, 120 .	,, 2 ,, .	0·13	92·6	712·3	on alkali land
,, 125 .	Lawn plot 1 part	0·18	158·4	880·0	on poor soil
,, 165 .	,, 1 ,, .	0·50	294·2	588·4	
Sesamum—					
Type 29 .	N. T. G. 8 part .	0·09	21·8	242·2	Sowing delayed by about a month owing to unfavourable weather.
Paddy—					
Type 31 .	Gonhri plots 8 & 9	0·32	430·9	1,346·6	
,, 52 .	,, ,, 10 & 11.	0·32	325·1	1,015·9	
Tobacco—					
Hybrid 142	Orchard 2A, 2B, and 2C part.	1·69	1,099·5	650·6	Leaf { Adversely affected by drought.
Harrison's Special.	Orchard 2C part	0·09	40·1	445·6	
Type 28 .	N. G. T. 2 part .	0·12	144·0	1,200·0	,,
,, 58 .	N. T. G. 2 ,, .	0·12	154·3	1,285·8	,,
,, 63 .	N. T. G. 2 ,, .	0·11	148·1	1,346·4	,,
Gram—					
Type 2 .	N. T. G. 6 and 7 part . .	0·12	141·9	1,182·5	
,, 25 .	,, .	0·50	773·5	1,547·0	
,, 28 .	,, .	0·12	209·8	1,748·3	
,, 53 .	,, .	0·12	224·2	1,868·3	
,, 17 .	N. T. G. 5 .	1·00	1,756·8	1,756·8	
,, 58 .	Lawn plot 3 .	0·34	462·9	1,361·5	

Crop	Plot	Area in acres	Out-turn of grain in lb.		Remarks
			Actual	Per acre	
Rahar—					
Type 5 .	Pentagonal part.	0·23	176·9	769·1	Sown with maize for fodder.
,, 15 .	,, .	0·90	742·6	825·1	,,
,, 24 .	,, .	0·25	80·2	230·8	,,
,, 41 .	,, .	0·17	144·0	847·1	,,
,, 51 .	,, .	1·05	940·1	895·3	,,
,, 80 .	,, .	0·22	281·8	1,280·9	,,
Hybrid A-5	,, .	0·13	152·2	1,170·8	,,
,, B-620	,, .	0·13	104·9	806·9	,,
,, C-15	,, .	0·12	141·9	1,182·5	,,
,, D-30	,, .	0·12	125·5	1,045·8	,,
,, E-50	,, .	0·12	125·5	1,045·8	,,
Culture 38	,, .	0·77	942·2	1,223·6	,,
Peas—					
S. 29 .	Orchard 1 A .	0·48	401·1	835·6	
Barley—					
Type 21 .	N. T. G. 10 .	1·78	3,575·3	2,008·6	
,, 21 .	Barah 5 . .	0·47	761·1	1,619·4	Sown late after-harvesting sann-hemp.
Oats—					
B. S. 1 .	Orchard 1-B .	0·48	1,174·6	2,447·1	
B. S. 2 .	Riverbank West	0·74	1,923·4	2,599·2	
B. S. 2 .	Orchard 6-B part	0·48	520·5	1,084·4	
Hybrid C	,, 2-D ,, .	0·35	567·8	1,622·3	
,, J .	,, 2-D ,, .	0·35	693·3	1,980·9	
,, J .	Pentagonal West border . .	0·13	279·8	2,152·3	
Hybrid G	Farm plot 1 .	1·00	903·1	903·1	
Hybrid G	Orchard 6-B part	0·48	477·3	994·4	
,, VII-54.	,, 6-B ,, .	0.12	129·6	1,080·0	
,, VII-578-45.	,, 6-B ,, .	0·12	141·9	1,182·5	
,, VII-94-53.	,, 6-B ,, .	0·12	107·0	891·7	
,, VII-265—55	,, 6-B ,,	0·12	131·7	1,097·5	
Lentils—					
III-86 .	S. T. G. 9 part .	0·19	139·9	736·2	
III-86 .	Pentagonal East border . .	0·11	40·1	364·5	
III-86 .	Barah 6 part .	0·14	166·6	1,190·0	
Sann-hemp—					
Local .	Outside Musahar 2 and 3 . .	0·40	129·6	324·0	
Hibiscus—					
Type 3 .	Outside Musahar 1 part . .	0·10	29·6	296·0	
,, 6 .	,, ,, .	0·10	32·9	329·0	
Linseed—					
Type 121.	N. T. G. 4 .	0·33	381·6	1,156·4	
,, 124.	N. T. G. 9 .	0·40	479·3	1,198·2	

Crop	Plot	Area in acres	Out-turn of grain in lb.		Remarks
			Actual	Per acre	
Ganja (Indian hemp)—					
Mixed seed	S. T. G. 1 .		67·9	133·1	
Cured drug T. 1 .	,, .		120·2	351·0	cured drug
Cured drug T. 2 .	,, .	0·51	41·7	351·0	
Cured mixed .	,, .		17·1		

III. PUBLICATIONS AND PROGRAMME OF WORK

Papers published during 1935-36

Bose, R. D. . . Studies in Indian barleys 3. Branched ears in barleys and their mode of inheritance. *Ind. Jour. Agri. Sci.*, Vol. V, pt. II, 1935, 155-164.

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Deshpande, R. B. . Studies in Indian Chillies 4. The inheritance of pungency in *Capsicum annuum* L. *Ind. Jour. Agri. Sci.*, Vol. V, pt. IV, 1935, 513-16.

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——— . . Wheat Rusts from the Viewpoint of Plant Breeding. *Agri. and Livestock, Ind.*, Vol. V, pt. II, 1935, 139-144.

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Pal, B. P. and Pushkar Nath.	Phyllody : A possible Virus Disease of Sesamum. *Ind. Jour. Agri. Sci.*, Vol. V, pt. IV, 1935, 517-522.
Shaw, F. J. F. . .	Indian Oilseeds. *Jour. Roy. Soc. Arts.*, Vol. LXXXIII, 4318, 1935, 945-968.
Shaw, F. J. F. and Pal, B. P.	Pusa 120 : A Wheat highly resistant to Yellow Rust. *Agri. and Livestock, Ind.*, Vol. VI, pt. II, 1936, 202-203.

Programme of Work for 1936-37

Work will be continued on the breeding and genetics of those crops which have formed the subject of this report. Preliminary work on three new crops, cotton, sorghum and soybean, will be commenced. Most of the experiments will be conducted either at Pusa or Karnal as the land at the new site at Delhi is not yet fit for experimental work.

Special attention will be given to yield trials and statistical methods.

Training of students will continue as in past years.

(2) BOTANICAL SUB-STATION, KARNAL*

I. INTRODUCTION

The Botanical Substation Scheme was originally sanctioned for a 5-year period which came to a close on the 30th September, 1935. From this date the scheme was renewed for a further 5-year period. It was decided that when the Imperial Institute of Agricultural Research was moved to Delhi, the Botanical Substation would be transferred from Karnal to Pusa.

Staff

Mr. Hukam Singh officiated as Superintendent of the Substation until the 15th May, 1936, when Mr. R. D. Bose relieved him, the Substation being formally transferred to Pusa on this date. With the exception of Mr. Bose who was appointed at Pusa to superintend the cultural operations for the *kharif* sowings and to carry out preliminary work in connection with the Substation, the rest of the staff continued to remain at Karnal in order to complete packing and seed distribution. The transfer of the Substation to Pusa is expected to be completed in early July.

Visitors

The visitors to the Substation included the Hon'ble Kunwar Sir Jagdish Prasad, and Mr. M. S. A. Hydari, the Hon'ble Member in charge and Joint Secretary, Department of Education, Health and Lands, respectively, the Vice-Chairman, the Agricultural Expert and the Secretary of the Imperial Council of Agricultural Research.

Season and Rainfall

On the whole the season was a favourable one for *rabi* crops. Most of the rainfall was received in July, August and September, the winter months being dry. This dry weather was mainly responsible for the early ripening of the crops this year, and for the fact that there was little lodging and rust disease in wheat.

The rainfall is shown in the following statement.

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*Financed by the Imperial Council of Agricultural Research.

Statement showing rainfall at the Botanical Substation, Karnal, during 1935-36

Months	Rainfall inches
June 1935	..
July	14·00
August	14·36
September	9·74
October	0·43
November	..
December	0·74
January 1936	0·09
February	0·86
March	0·22
April	0·11
May	0·74
Total rainfall	41·29

Lay-out

A block of about 18 acres in the general area was levelled during the winter. Levelling of portions of roads in the general area and in the paddy area was also done. The drainage of the building area was improved.

II. INVESTIGATIONS

Wheat (*Triticum vulgare* Host.)

The yield trials of Pusa 120 and Pusa 165 at various farms in the United Provinces and in the Punjab were continued in 1934-35, and the results tend to support the conclusions arrived at last year. The results for 1935-36 are not yet available.

In the year under report a new yield trial was laid down to test the new Federation hybrids P. 121, P. 122, P. 125, and P. 126. All these are early, bearded and non-shattering. They were compared with Pusa 80-5 and Pusa 165 and the results are presented in Table I.

TABLE I

Yield trial with early varieties of wheats, 1935-36.

Comparison of Pusa wheats..—P. 80-5, P. 121, P. 122, P. 125 P. 126, and P. 165.

Sowing plan with yield per plot in lb.

N.

Experimental Area Plot No. 6

P. 121 43·25			P. 125 57·75		
P. 126 64·25			P. 80-5 53·75		
P. 125 61·00			P. 121 63·50		
P. 165 44·50			P. 122 31·50		
P. 80-5 47·75			P. 126 61·00		
P. 122 36·25			P. 165 51·50		
P. 126 65·00	P. 121 57·75	P. 125 46·75	P. 122 30·50	P. 165 47·50	P. 80-5 40·00
P. 122 35·75			P. 165 48·25		
P. 80-5 47·00			P. 126 46·50		
P. 126 49·25			P. 122 24·25		
P. 125 54·00			P. 121 35·00		
P. 165 52·00			P. 125 48·00		
P. 121 50·25			P. 80-5 43·50		
P. 80-5 53·00	P. 122 29·50	P. 121 45·00	P. 165 44·25	P. 125 47·50	P. 126 40·50

System of replication—Randomized blocks (6 varieties and 6 replications) Area of each ultimate plot—56′ × 17′=1/45 acre approximately.

Seed sown on — 25th October 1935.

Harvested on — 11th April 1936.

Summary of results (Grain yields)

Yield	Mean yields in lb.						General mean	Standard error of mean difference	Whether general effect of treatment is significant by "Z" test	Critical difference for significance in lbs. per acre at P = 0·05
	P. 80-5	P. 121	P. 122	P. 125	P. 126	P. 165				
Per acre.	2137·50	2210·85	1408·05	2362·50	2448·90	2160·00				
Per cent on general mean	100·76	104·22	66·38	111·37	115·44	101·82	2121·30	163·35	Significant	336·60

Conclusion—P. 126 = P. 125 = P. 121 = P. 165 = P. 80-5 > P. 122.

The order of merit as regards yield is Pusa 126, Pusa 125, Pusa 121, Pusa 165, Pusa 80-5 and Pusa 122. The differences between the mean yields of the wheats, however, are not significant except in the case of Pusa 122 which is definitely inferior to the others.

In another yield trial the late-maturing hybrids, Pusa 123 and Pusa 124, were tested against Pusa 114, Pusa 120, Punjab 8A and Punjab C. 518. The former out-yielded Pusa 114, Pusa 120 and Punjab 8A, but were surpassed by Punjab C. 518.

The varietal trial with Pusa 80-5, Pusa 114, Pusa 120, Pusa 165, Punjab C. 518, Punjab C. 591 and Cawnpore 13 was conducted for the third time but the experiment was vitiated by the defective germination of some of the varieties. This trial will therefore be repeated in the coming year.

Selection work with Pusa 120 wheat is in progress with the object of securing a non-shedding strain. A number of rogue plants found in Pusa 111 were under study, and it is thought that some of them may prove of economic value.

As in the previous year, the Statistician of the Imperial Council of Agricultural Research laid down an experiment to determine the most suitable size of plot for varietal trials in wheat, and was given necessary assistance. Facilities were also extended to the Imperial Mycologist for an investigation on bunt.

Barley (*Hordeum vulgare* L.)

A yield trial of five Pusa and two Lyallpur barleys was repeated for the third year in succession: the results are given in Table II.

TABLE II

Yield trial with Pusa and Lyallpur Barleys, 1935-36

Comparison of Pusa types 4, 13, 16, 18 and 21 and Lyallpur types 4 and 5

Sowing plan with yields per plot in lb.

N.

Experimental Area Plot No. 5

T. 16 36·00	T. 4 34·75	L. 5 52·75	T. 13 69·25	T. 21 61·75	L. 4 50·00	T. 18 39·25
T. 13 60·75	T. 21 65·25	T. 16 63·00	L. 4 57·75	T. 18 61·50	T. 4 42·75	L. 5 41·00
L. 4 44·50	T. 18 48·25	T. 13 66·25	T. 4 40·50	L. 5 40·50	T. 21 45·00	T. 16 44·75
T. 21 59·75	L. 5 59·25	T. 4 48·50	T. 16 62·00	T. 13 59·25	T. 18 56·75	L. 4 43·50
T. 4 40·00	T. 13 67·50	L. 4 53·50	T. 18 58·75	T. 16 59·00	L. 5 53·25	T. 21 45·25
L. 5 43·00	T. 16 52·75	T. 18 53·25	T. 21 50·50	L. 4 48·00	T. 13 60·75	T. 4 38·25
T. 18 41·50	L. 4 40·25	T. 21 43·50	L. 5 48·50	T. 4 35·50	T. 16 51·00	T. 13 45·75

System of replication—Latin Square (7 × 7).

Area of each ultimate unit—$49' \times 15' = 1/59$ acre approximately.

Seed sown on—6th and 7th November 1935.

Harvested on—12th April 1936.

Summary of results (Grain yields)

Yield	Mean yield in lb.							General mean	Standard error of mean difference	Whether general effect is significant by "Z" test	Critical difference for significance in lbs. per acre at P=0·05
	T. 4	T. 13	T. 16	T. 18	T. 21	L. 4	L. 5				
Per acre	2,381·24	3,620·24	3,105·76	3,027·88	3,127·00	2,844·39	2,850·88	2,993·91	260·78	Significant	408·87
Per cent on General mean.	79·54	120·92	103·74	101·13	104·45	95·01	95·22				

Conclusions :—

T. 13 is superior to all other types of barleys.

T. 4 is inferior to all other types of barleys.

The differences of all other mean yields are not statistically significant.

It is evident from the results of this year and of the two preceding years that Pusa Type 13 is particularly suitable for Karnal conditions. It may be expected to do well in tracts with conditions of soil and climate similar to those obtaining in Karnal.

Work is also in progress with the object of producing new strains suitable for the eastern Punjab. A number of pure lines has been grown and studied for the last two years, and it may be stated that certain of them show definite promise.

Paddy (*Oryza sativa* L.)

A yield trial with paddy Types 18, 97, 125, 130, 137 and 164 was again conducted. As in the previous year, the fine-grained selections, T. 125 and T. 130, made at Karnal proved superior to the standard early varieties, T. 18 and T. 97, but were out-yielded by T. 164, a red-grained, coarse paddy. The yield trial results are given in detail in Table III.

Table III

Paddy yield trial (varietal), 1935-36

Comparison of T. 18, T. 97, T. 125, T. 130, T. 137 and T. 164

Plan and yields in lb. per plot

North

T. 97	20·75	T. 125	35·00	T. 130	33·00
T. 18	21·00	T. 164	40·75	T. 18	31·25
T. 130	29·00	T. 137	29·50	T. 97	27·00
T. 125	29·75	T. 97	24·75	T. 164	40·50
T. 164	34·75	T. 18	29·00	T. 137	28·50
T. 137	27·50	T. 130	33·25	T. 125	32·25
T. 125	31·00	T. 97	29·75	T. 164	42·75
T. 18	30·00	T. 137	30·00	T. 125	38·50
T. 164	35·50	T. 130	28·50	T. 97	26·50
T. 97	26·25	T. 125	32·50	T. 18	30·75
T. 137	27·00	T. 164	34·00	T. 137	31·75
T. 130	31·50	T. 18	30·50	T. 130	33·00

System of replications—Randomized blocks (6 varieties and 6 replications).

Area of each plot—13′ × 40′ = 1/83·8 acre.

Seedling transplanted on—16th July 1935.

Harvested on—31st October 1935.

Summary of results (grain)

—	Mean yields in lb.						General mean	Standard error of difference	Significance of "*Z*" test	Critical difference for significance (per acre) in lbs.
	A T. 18	B T. 97	C T. 125	D T. 130	E T. 137	F T. 164				
Per acre . .	2,409·25	2,164·55	2,779·64	2,628·80	2,433·55	3,187·75	2,600·31	1,05·58	Significant	294·27—1 per cent
Per cent on general mean.	92·65	83·24	106·89	101·01	93·58	122·59	100·00	..	..	217·51—5 per cent.

Conclusions :—T. 164 > T. 125=T. 130=T. 137=T. 18>T. 97(5 per cent).

T. 130 > T. 137>T. 18 (5 per cent).

T. 137 > T. 18 and T. 97.

T. 18 > T. 97.

A preliminary experiment was carried out with Types 18, 97, 125 and 130 to see whether transplanting at regular intervals (one foot between rows and one foot between plants in the row) gives better results than the local practice in which no regular spacing is maintained. Although the results cannot be subjected to statistical analysis, they indicated that transplanting paddy at a regular spacing is likely to promote higher outturns of grain.

Gram (*Cicer arietinum* L.)

The following crosses were grown and studied :—

T. 35 × T. 2 (F_3 generation)

T. 2 × T. 3 (F_3 ,,)

T. 9 × T. 13 (F_2 ,,)

T. 13 × T. 9 (F_2 ,,)

In the T. 35 × T. 2 cross, the F_3 results confirmed those obtained in F_2 ; the orange seed colour of T. 35 behaves as a simple recessive to the white colour of T. 2. The inheritance of seed-colour and other characters in the T. 9 × T. 13 cross appears to be complex and is being investigated.

The study of the simple-leaved plant reported previously was continued. It will be recalled that out of the 13 plants raised from its seed last year, ten were simple-leaved and three normal-leaved. Unfortunately the latter died before producing seeds. The progeny of the former was grown this year and the segregation was not as simple as originally anticipated. Out of the ten plants, four bred true for simple-leaved condition, and the remaining six segregated as follows :—

	Simple-leaved	Normal-leaved (compound)
Observed frequency . . .	479	31·0
Expected on a 15 : 1 ratio . .	468	31·9

It was noted that all the simple-leaved plants possessed a few compound leaves. This study will be continued.

The mutant with very narrow leaves reported last year in Type 25 was found to breed true.

A yield trial with Pusa Types 17, 25, 48, 58, 67 and a local variety was conducted for the third year and the results show that, under the conditions of the experiment, Type 17 was inferior to the other Pusa types in yielding capacity; the differences among the other types are not statistically significant. The results are summarised in Table IV.

TABLE IV

Yield trial of Pusa Grams, 1935-36

Comparison of Pusa gram types 17, 25, 46, 58 and 67 against Karnal local

Sowing plan with yield per plot in lb.

N

Experimental Area Plot No. 4

T. 17 30·50	T. 25 37·00	T. 46 37·75	T. 58 40·25	T. 67 23·25	Local 24·00
T. 58 29·00	Local 22·75	T. 67 12·00	T. 25 24·75	T. 46 33·50	T. 17 25·00
T. 46 38·00	T. 67 35·25	T. 17 34·00	Local 36·75	T. 25 44·00	T. 58 40·75
Local 41·25	T. 17 36·25	T. 25 37·75	T. 67 34·25	T. 58 40·00	T. 46 42·75
T. 67 41·50	T. 58 46·25	Local 42·50	T. 46 41·50	T. 17 35·50	T. 25 45·25
T. 25 47·75	T. 46 42·50	T. 58 42·75	T. 17 33·50	Local 44·25	T. 67 47·25
T. 67 48·00	T. 17 41·25	T. 46 46·75	Local 43·75	T. 25 49·00	T. 58 45·75
Local 35·25	T. 46 37·00	T. 67 46·00	T. 17 27·75	T. 58 32·50	T. 25 38·25

System of replication—Randomized blocks (6 varieties and 8 replications).

Area of each ultimate unit—41′ × 14′ = 1/76 acre approximately.

Seed sown on—30th September 1935.

Harvested on—17th April 1936.

Summary of results (Grain yields)

Yield.	Mean yield in lb.						General mean	Standard error of mean difference	Whether general effect is significant by "Z" test	Ceritical difference for significance in lbs. per acre at P=0·05
	T. 17	T. 25	T. 46	T. 58	T. 67	Local				
Per acre . .	2505·72	3075·72	3037·72	3014·16	2731·44	2759·56	2854·05	173·28	Significant	354·16
Per cent of general mean.	87·80	107·78	106·44	105·61	95·70	96·69				

T. 17 is inferior to Types 25, 46 and 58 at the 1 per cent level.

The other types show no significant differences even at the 5 per cent level.

Brassicae (*Brassica* spp.)

The self-fertile types of *sarson* and *rai* isolated at Pusa were grown and studied with the aim of selecting out the best types for further trial. The other types of mustard were maintained.

The F_2 generations of crosses between *B. juncea* var. *juncea* and var. *rugosa* were studied. Some plants with non-lobed leaves and narrow midrib typical of *B. juncea* var. *cuneifolia* were found and this fact suggests that *cuneifolia* possibly has been produced as the result of natural crossing between *rugosa* and *juncea*. The lyrate shape and narrow midrib characters of var. *juncea* are dominant, but the inheritance is complex.

Cawnpore *sarson* T. 30, Lyallpur yellow *sarson* A, *Rai* O. B. 1, and a brown *sarson* selection were grown and compared with the Pusa types, in a preliminary trial. The latter gave better yields. It is hoped to carry out a regular trial next year.

Flax (*Linum usitatissimum* L.)

A quantity of flax seed was multiplied at the request of the Assistant Fibre Expert, Bengal.

III. SEED DISTRIBUTION

The popularity of improved seeds of wheat, gram and other crops is steadily increasing, and the demand for such seeds now greatly exceeds the available supply. The seeds distributed during the year under report are shown in Table V.

TABLE V

Statement of seed distributed from Karnal during the year 1935-36

Crop	Variety	Quantity in lb.
Wheat	P. 4	5,463·8
	P. 12	2,635·2
	P. 12-2	205·7
	P. 80-5	20,736·1
	P. 111	4,155·4
	P. 112	51·4
	P. 114	6,023·4
	P. 120	2,880·0
	P. 165	5,645·8
	P. 121	16·5
	P. 123	16·5
	P. 124	16·5
	P. 126	16·5
Gram	T. 58	432·0
	T. 25	123·4
	T. 28	24·7
Peas	14-1	567·8
Linseed	H. 10	5·1
	H. 68	5·1
	H. 21	5·1
	H. 55	5·1
	T. 12	30·9
	T. 124	5·1
Flax	Pusa	61·7
Oats	Hybrid J.	1,532·6
	,, G.	750·9
	,, C.	750·9
	B. S. 2	339·4

TABLE VI

Statement showing the crop returns of the Botanical Substation, Karnal, for the year 1935-36

Area	Crop and varieties	Plots	Area in acres	Actual yield in lb.	Calculated outturn per acre in lb.	Remarks.
General Area	Wheat—					
	P. 4	11 to 13	3·49	3,702·90	1,061·00	Crop heavily attacked by black rust.
	P. 4	14, 15 & 32 to 34	6·17	10,322·80	1,673·06	
	P. 12	6 to 9	4·56	8,286·20	1,817·15	
	P. 80-5	24 to 30	13·77	23,830·00	1,730·57	
	P. 111	39 to 41	6·22	13,968·00	2,245·66	
	P. 114	38	2·56	6,019·20	2,351·25	
	P. 114	2 to 5	4·09	8,024·90	1,962·08	
	P. 120	31	1·55	3,052·80	1,969·55	
	P. 121	16	0·58	892·80	1,539·31	
	P. 126	16	0·39	662·40	1,698·46	
	P. 165	35 to 37	6·72	13,126·70	1,953·38	
	Barley—					
	T. 21	10	1·24	3,758·40	3,030·97	
	Gram—					
	T. 17	17 to 18	4·09	9,111·10	2,227·65	
	T. 25	21 to 23	7·07	9,008·30	1,274·16	
	T. 58	19 and 20	5·31	10,343·30	1,947·89	
	Flax—					
	Dacca	1	0·18	57·60	320·00	
	Pusa	1	0·35	164·60	470·29	
Experimental Area	Wheat—					
	P. 4	1	0·18	267·40	1,485·55	
	P. 12	1	0·18	251·00	1,394·44	
	P. 80-5	1	0·18	224·20	1,245·55	
	P. 111	1	0·18	269·50	1,497·22	
	P. 112	1	0·18	261·30	1,451·67	
	P. 113	1	0·18	251·00	1,394·44	
	P. 114	2	0·18	456·70	2,537·22	
	P. 120	2	0·18	374·40	2,080·00	
	P. 121	9	0·35	501·90	1,434·00	
	P. 123	9	0·35	504·00	1,440·00	
	P. 124	9	0·03	45·30	1,510·00	
	P. 126	9	0·35	438·20	1,252·00	
	P. 163	2	0·18	454·60	2,525·55	
	P. 165	2	0·36	987·40	2,742·78	
	Gram—					
	T. 2	3	0·30	611·00	2.036·67	
	T. 28	3	0·30	901·00	3,003·33	
	Paddy—					
Paddy Area	T. 18	5c, 6c	0·56	1,302·20	2,325·36	
	T. 97	1b, 1c, 2b, 2c, 3b and 3c.	1·49	2,281·30	1,531·07	
	T. 125	2d, 3d, 4d, 5d and 6d.	2·17	4,595·70	2,117·83	
	T. 129	6b	0·26	390·90	1,503·46	
	T. 130	2a, 3a, 4a and 6a.	1·18	2,491·20	2,111·19	
	T. 137	1a	0·05	63·80	1,276·00	

REPORT OF THE SECOND ECONOMIC BOTANIST

IN CHARGE OF

WHEAT-BREEDING SECTION OF THE SCHEME FOR INVESTIGATIONS ON CEREAL RUSTS*

(B. P. Pal, M. Sc., Ph.D., F.L.S.)

I. INTRODUCTION

It was felt in 1934 that sufficient data concerning the number and distribution of wheat rust races in India had been secured as a result of Dr. K. C. Mehta's investigations to enable breeding work to be initiated, and a wheat-breeding section was incorporated in the Scheme for Investigations on Cereal Rusts when it was renewed and extended by the Imperial Council of Agricultural Research for a further three-year period in 1935. This provided for the breeding of rust-resistant wheats in the Botanical Section of the Imperial Agricultural Research Institute and at a substation at Simla, under the supervision of the Second Economic Botanist and with the collaboration of Dr. K. C. Mehta.

The wheat-breeding scheme officially commenced on the 7th April, 1935, when Mr. M. A. Aziz was appointed Wheat Breeding Assistant with headquarters at Simla, but actually work was started in October 1934 when wheats to be used as parents for making crosses were sown both at Pusa and at Simla. The list of crosses made was given in the preliminary report on the Scheme which was submitted last year. The present report deals with the crop year 1935-36.

Land, Lay-out and Equipment

About two acres of land, in three terraces, attached to the Rust Research Laboratory at "Flowerdale", Simla East, have been leased for three years. The land was levelled, fenced and made suitable for experimental work.

A large amount of laboratory apparatus including a microscope and a microtome was received on loan from the Imperial Agricultural Research Institute by kind permission of the Director.

Season

The season was a favourable one on the whole. There was a dry spell in the second half of January when the crop required irrigation, but it was not possible to give this because of lack of irrigation facilities. Warm weather when the crop was maturing was responsible for an early harvest.

* Financed by the Imperial Council of Agricultural Research.

II. INVESTIGATIONS

Crosses

As explained in the preliminary report already referred to, a large number of crosses was made because at the time when the hybridization work was in progress, Dr. Mehta's investigation on the resistance of parental types was still in progress. As the crosses were easy to make, a large number were made and from these a few have been selected for further breeding, the selection being based on the results obtained by Dr. Mehta on the resistance of parental types. In this way a year has been saved in the progress of the work.

As the object of the scheme is to produce not merely rust-resistant wheats, but those which shall combine this property with other desirable economic qualities, the remaining crosses are also being grown and studied, although it may not be possible for practical reasons to subject them to the same rigidly-controlled tests for resistance to rust which will be applied to the crosses mentioned in the preceding paragraph. Among the qualities on which special stress is to be laid is early maturity, as this is of great importance in the Central Provinces, Bombay and certain other areas.

During the year under report, the F_1 generations of the crosses were grown, and certain of these were tested in the seedling stage by Dr. Mehta against the various physiologic forms of the three rusts. Resistance was found to be dominant in certain cases, and susceptibility in other cases.

The crosses made with the object of securing resistance to brown and yellow rust involved hybridization among *vulgare* varieties and vigorous and fertile F_1's were obtained. With black rust, however, where interspecific crosses between *T. dicoccum* (Khapli) and *vulgare* wheats were necessary, there has been, as was to be anticipated, considerable difficulty. Thin, shrivelled grains were obtained from the Khapli crosses which with few exceptions either failed to germinate, or died in the seedling stage. In a very few cases plants lived long enough to produce small ears but these proved sterile and only one plant gave three grains. The crosses have been repeated this spring on a larger scale. If the F_1's again prove sterile, it may be necessary to transfer the resistance of Khapli first to *durum* wheat with which it crosses fairly readily, and then to attempt to transfer it from *durum* to *vulgare*. Alternatively it may be possible to make use of the mature resistance of certain *vulgare* varieties to black rust. Dr. Mehta carried out preliminary tests of mature resistance last year and has kindly undertaken to repeat them on an extended scale next season.

Exotics.—A collection of 106 wheat samples from Great Britain, Australia, America, Germany, Russia, etc., was under study with the object of discovering strains suitable for breeding work.

Hill wheats.—Forty single ear samples obtained from various localities in the hills of North India were also under study.

Possibility of taking two crops a year.—This possibility was tested on a small scale, but the experiment was not a success as the wheats did not grow well in the rainy season.

III. ACKNOWLEDGMENT

The Officers of the Imperial Council of Agricultural Research have been very helpful and thanks are due to them. The writer is likewise grateful to the Director of the Imperial Agricultural Research Institute and to Dr. K. C. Mehta for providing the necessary facilities.

Mention must also be made of the Agricultural Botanists and other scientists abroad who have been good enough to supply seed samples of wheat varieties grown in their countries. Dr. B. B. Mundkur of the Mycological Section, Imperial Agricultural Research Institute, also supplied some seeds.

IV. PROGRAMME OF WORK FOR 1936-37

Breeding work will continue on the lines indicated. The F_2 generations of selected crosses will be grown and studied, and also the F_1 generations of the Khapli crosses which have been repeated.

REPORT OF THE SECOND ECONOMIC BOTANIST

IN CHARGE OF

POTATO BREEDING SCHEME FOR NORTHERN INDIA*

(B. P. Pal, M.Sc., Ph.D., F.L.S.)

I. INTRODUCTION

The Advisory Board of the Imperial Council of Agricultural Research which met in 1934 came to the decision that most of the important problems of potato growing in Northern India could be studied at a central research station, and a scheme submitted by the Director of the Imperial Agricultural Research Institute whereby potato breeding would be carried out by the Second Economic Botanist at the Imperial Agricultural Research Institute and at a substation in the hills, the latter to be financed by the Imperial Council of Agricultural Research, was approved. The scheme came into operation on the 1st April 1935, when Mr. Pushkar Nath, M.Sc. (Hons.), was appointed Assistant-in-charge of the substation with temporary headquarters at Simla. Pending the final selection of a site for the substation, accommodation at the Rust Research Laboratory at Simla was kindly provided by Dr. K. C. Mehta, and a small temporary staff was recruited to assist the Assistant-in-charge.

The main object of the Scheme is the production of new varieties with desirable characters such as immunity or high resistance to blight, and virus diseases, good keeping quality, etc. The attainment of this object involves the study of both Indian and foreign (South and Central American species) material to discover the forms most likely to be of value under Indian conditions, as parents for crossing. To ensure success in crossing, flowering, fertility and sterility, and related problems will have to be also studied.

In this report no attempt is made to separate the work done at the main station at Pusa from that carried out at the hills substation (Simla), as the studies at the two places are complementary, and have to be considered together in order to obtain a connected picture.

* Financed by the Imperial Council of Agricultural Research.

II. CO-OPERATIVE EXPERIMENT TO DISCOVER THE MOST SUITABLE SITE FOR THE HILLS SUBSTATION

As it was not known as to what would be the most suitable site for the hills substation, it was decided to conduct preliminary trials with a standard set of varieties at Simla, Murree Hills and the Kulu Valley in the Punjab, at Chaubattia (Ranikhet) and Khabrar (Ramgarh) in the United Provinces, and at Shillong in Assam, with a view to obtaining data on the relative amount of flowering and berry formation at these places. The trials in the Kulu Valley were spread out over three places, *viz.*, Katrain, Manali and Kothi, so that altogether the same set of varieties was grown at eight different places. Simla was temporarily made the headquarters of the work in the hills so that valuable potato material received from abroad could be adequately handled. The work at Simla was under the direct supervision of the Second Economic Botanist, Pusa, but the trials at the other stations were carried out with the co-operation of the Directors of Agriculture of the Provinces concerned. A detailed account of this co-operative experiment and the results obtained has been printed separately*, and it will suffice to mention here that flowering and berry formation were satisfactory at Simla, Chaubattia, Katrain and Manali. Out of these stations, Simla, was ultimately selected to be the site of the hills substation of the Scheme for reasons of administrative convenience, and also because of other considerations, *e.g.*, availability of electricity for green-houses, etc.

III. STUDY OF INDIAN AND EUROPEAN *TUBEROSUM* MATERIAL

Two hundred and sixty-three samples of potatoes received from all over India were studied. These comprised *desi* varieties as well as European varieties which have been grown in India. As a rule each " culture " was small, only a very limited number of tubers of each kind having been received and some having rotted in storage.

After duplicates have been eliminated, the remaining varieties will be classified, and the best ones selected for breeding work.

A large number of seedlings were raised at Pusa from true seed of the local variety (" Pusa White ") and of the Coonoor White variety. Seed of the latter was kindly supplied by the Nanjanad Potato Station. The study of these seedlings will be continued.

IV. STUDY OF FOREIGN (SOUTH AMERICAN AND CENTRAL AMERICAN SPECIES) POTATO MATERIAL

A considerable amount of material of the South American and Central American species and of hybrids between these and

* " Report on the co-operative potato trials conducted in connection with the Potato Breeding Scheme for Northern India in 1935 ", by the Second Economic Botanist, Imperial Institute of Agricultural Research, Pusa.

S. tuberosum has been received through the courtesy of Agricultural Botanists in Russia, America, Germany and England. Particular mention must be made of Dr. P. S. Hudson of the Imperial Bureau of Plant Genetics, Cambridge, and Dr. R. N. Salaman of the Potato Virus Research Institute, Cambridge, who have shown great interest in the scheme and have rendered invaluable assistance in procuring potato material.

Material of the following species is now available :—

S. andigenum	*S. goniocalyx*
S. Antipoviczii	*S. Jamesii*
S. aracc papa	*S. leptostigma*
S. Caldasii glabrescens	*S. Maglia*
S. Candelarianum	*S. neoantipoviczii*
S. chacoense	*S. otites*
S. Commersonii	*S. polyadenium*
S. curtilobum	*S. Reddickii*
S. demissum	*S. stenotomum*
S. edinense	*S. subtilius*
S. Fendleri	*S. tuberosum* (from S. America).

Hybrids of probable economic value between some of these species (especially *S. andigenum*) and commercial varieties of *tuberosum* have also been received.

The amount of material of each kind under study varies greatly and, in many cases, is extremely little. Until this material is multiplied, therefore, it is not possible to undertake tests of resistance to diseases, etc. Such tests, however, will be carried out with the co-operation of the Mycological Section of the Imperial Institute of Agricultural Research, as soon as sufficient material becomes available.

Most of the species (other than *S. tuberosum*) have been reported by workers in Russia, etc., to require "short-day" conditions. Elaborate arrangements for curtailing daylight were not possible at the temporary substation, but plants of such species were covered for the necessary period with improvised dark cloth covers. Surprisingly enough, plants, which were left uncovered as controls, also formed tubers. The matter requires further investigation.

Plants of about half the number of species given in the list above were raised from true seed. The rest of the material was obtained from abroad in the form of tubers.

V. STUDY OF FLOWERING, POLLEN FERTILITY AND BERRY PRODUCTION

Most of the cultures flowered when grown at Simla, and some formed berries. Notes of flower and berry production have been recorded in detail.

A preliminary study was also made of the pollen of a number of Indian and foreign varieties, as such a study is necessary to discover what varieties can be used as males for crossing work. Germination tests *in vitro* are, however, rather difficult as potato pollen appears to be extremely sensitive to external conditions.

In order to gain experience of crossing technique, a number of crosses were attempted although as information regarding the value of foreign species for breeding under Indian conditions is not yet available, it is not yet possible to plan crosses for a definite purpose. In making crosses, however, those species were selected which have been found in other countries, to possess characters of economic value. Should these species therefore be subsequently found to maintain these characteristics (*e.g.*, disease resistance) under Indian conditions, it will be possible to use the crossed seed which has been obtained. The following crosses were successfully made and a quantity of seed obtained :—

Pusa White × *S. demissum*

Pusa White × *S. neoantipoviczii*

Coonoor White × *S. andigenum*

President × *S. andigenum*

VI. MISCELLANEOUS

Dormancy of Tubers

Experiments have been carried out at Pusa to determine the effect of several physical and chemical treatments upon dormancy in potato tubers. The data however are not yet fully analysed.

Potato Storage

At the suggestion of Sir Bryce Burt samples of tubers were sent to the Cold Storage Research Station at Kirkee where, by courtesy of Dr. Cheema and his Assistant Dr. Karmarkar, they were stored at different temperatures. The final results of this test of course cannot yet be given but the indications are that, as expected, rotting in storage is materially reduced at the lower temperatures.

VII. ACKNOWLEDGMENTS

In addition to those whose assistance has already been acknowledged in the body of the report, special thanks are due to Sir Bryce Burt and Dr. F. J. F. Shaw through whose efforts it has been

possible to obtain valuable material from abroad and to arrange for the early commencement of work on the scheme.

VIII. PROGRAMME OF WORK FOR 1936-37

As it was not possible to acquire a suitable site for the sub-station at Simla in time, temporary arrangement has been made to carry out the work for this season on about four acres of land attached to Villa Harding, immediately below the Rust Research Laboratory at Simla.

Work will be continued on the same lines as last year, the study being extended to include new material received since then.

REPORT OF THE SUGARCANE EXPERT

(Rao Bahadur T. S. Venkatraman, B.A.)

I. CHARGE AND STAFF

I held charge throughout the year except during the undermentioned periods when the Second Cane Breeding Officer, Mr. N. L. Dutt, officiated for me :—

(1) A little over two and half months (2nd August to 24th October 1935) when I was deputed to Australia to attend the Fifth Congress of the International Society of Sugarcane Technologists and permitted to revisit Java during return journey.

(2) Fifteen days' leave from 9th to 23rd December 1935.

Mr. N. L. Dutt held charge of the office of the Second Cane Breeding Officer throughout the year.

The Sugarcane Geneticist, Dr. E. K. Janaki Ammal, was deputed to attend the International Botanical Congress at Amsterdam, the Imperial Botanical Conference at London and to work for two months at the John Innes Horticultural Institution, Merton. This involved a total period of absence out of India for a little over four months (8th August to 23rd December 1935).

The term of the Sub-station at Karnal, which expired on 1st April 1936, was extended for a further period of three years.

II. SUGARCANE BREEDING (MAINLY SUB-TROPICAL TYPES)*

1. The Breeding Programme

Eleven bulk economic crosses were made during the year, yielding about a lakh and half of seedlings. The experimental crosses made included a few of somewhat unusual interest. One is a cross between *Vellai* and *S. robustum* the wild rather thickish type of *Saccharum* collected from New Guinea. Another is a cross between *Vellai* (*S. officinarum*) and *S. arundinaceum* ; the resultant seedlings show obvious traces of the pollen parent in the shape and vestiture of the ligule. A third is a cross which combines in itself *S. officinarum* and two different types of *Sorghum*.

*The breeding of tropical types is detailed in the Report of the Second Cane Breeding Officer (Section IX).

2. Early Season Good Tonnage Seedlings

A careful stock-taking of the varietal situation in subtropical India indicates an "early" high tonnage cane as an immediate desideratum. The existing early types are not satisfactory in tonnage and the tonnage canes are not sufficiently early. During the year it was possible to release for trial a few types combining earliness and fairly high tonnage. It may not be possible to combine in such "early" canes tonnage as high as the best of the mid-season types but some advance over existing types might be possible.

3. Parents

During the year Co. 421 was added to the list of parents yielding vigorous types. Co. 508, a seedling of Co. 214, has again demonstrated its value in the breeding of "early" canes with satisfactory sugar values. Some of its hybrids recorded as much as 17 per cent sucrose in October and a few of them over 20 per cent sucrose when fully ripe. The *Sorghum* hybrids are showing remarkable figures in the matter of sucrose, one of them recording over 21 per cent in bulk samples. Certain of these are now fertile and cross freely with other sugarcanes. The hybrid Co. 354 has been successfully crossed with Co. 331, a vigorous "late" cane of erect habit, and the seedlings are recording satisfactory juices.

4. Intergeneric Hybrids with Sorghum

The hopes entertained in early years of early maturity being secured by crossing with *Sorghum* have not been realized under sub-tropical conditions. It would now appear that the problem will have to be tackled on a broader front bringing in other types of *Sorghum* and other *Saccharums* for increasing vegetative vigour. Under North Indian conditions good growth during rains would appear to depend on a fair amount of growth in the plant at the end of summer. The present *Sorghum* hybrids do not show this character. When *S. spontaneum* was employed in sugarcane hybridization it needed a certain amount of what is termed "Nobilization" before economic types were obtained. The *Sorghum* hybrids might need similar handling.

High juice qualities and capacity to keep up the quality for fairly long periods are two of the important characteristics secured from this intergeneric hybridization.

III. CYTO-GENETIC STUDIES* (under Dr. E. K. Janaki Ammal)

1. Breeding Technique

Any question regarding the fundamental breeding behaviour of sugarcane can be answered only by the use of parents whose

* The work described in this section is financed by the Imperial Council of Agricultural Research.

genetical and cytological 'make up' is known. This is not quite so essential in the breeding of economic types. An attempt was, therefore, made to develop a technique which may ultimately bring *Saccharum* in line with other crop plants.

(1) Bagging all day long was found not good for seed setting; hence the arrows were freed of bags after 12 noon to dusk when they were again protected from foreign pollen. (2) The use of a strong spray of water to wash out the pollen from unemasculated flowers before dusting with pollen of another parent was tried in the case of *Erianthus*. (3) The use of dilute formic acid for preserving cut arrows was tried. Though the arrows in solution survived longer than those in water, they did not live long enough to seed. (4) Though rather laborious and delicate on account of the minuteness of the flowers emasculation has been successfully carried out in many varieties.

2. Programme of Studies

Cyto-genetic work on sugarcane suffers from two handicaps. One is the very large number of chromosomes found in some of the latest seedling canes; P. O. J. 2725, for instance, has 106. The second is the fact that most canes in cultivation are complex hybrids which renders it difficult to establish pure lines. An attempt was, therefore, made during the year to study the chromosome structure and behaviour in the comparatively simpler forms of the genus *Saccharum* and to effect controlled crosses after proper emasculation.

3. Crosses made

The crosses effected may be broadly classified into (1) intraspecific crosses between the different chromosomal types of *S. spontaneum*, (2) interspecific crosses between the Coimbatore cane Vellai, as mother parent, and types of *S. spontaneum* and *S. robustum*, and (3) intergeneric crosses between (i) *S. spontaneum* and *Sorghum Durra*, (ii) *S. officinarum* and *Imperata* and (iii) *S. spontaneum* and *Erianthus*.

Back crosses.—The cane Co. 205, which is a cross between Vellai and *S. spontaneum*, was repeatedly back-crossed with *S. spontaneum* bringing in altogether three doses of the *spontaneum* blood. The resultant plants closely resemble *S. spontaneum*. Kassoer, which is supposed to be a cross between a thick cane and *S. spontaneum* (*Glagah*), was back-crossed with *Glagah* and with *S. spontaneum* of Coimbatore. There is greater variation in these than in the back-cross of Co. 205 with *S. spontaneum*.

4. Some results

The intergeneric cross between *S. spontaneum* and *Sorghum* has since flowered. Presence of the awned IV glume (a *Sorghum*

character) and the chromosome numbers leave no doubt about the genuineness of the cross.

One rather interesting phenomenon revealed by the studies is that, whereas there is a doubling of chromosomes on the mother side in the case of certain crosses, such a doubling does not occur in others.

Progenies of comparatively simple types of *S. spontaneum*, even when selfed, show wide variations in the morphological characters of the ligule and the bud and in sucrose.

IV. OTHER INVESTIGATIONS

1. Maturity determination

The Chemistry Assistant, Mr. K. V. Gopala Iyer, is engaged in a series of periodic analyses to ascertain the most reliable method for determining maturity in sugarcanes. The analyses are started well before the maturing time for canes and continued long after the cane crushing season. A portion of the plot is being kept for another season as well. A series of periodic analyses is found more reliable than analyses at one particular time for maturity determination. Secondly, it would appear somewhat unreliable to depend on a single value. Amount of reducing sugars taken in conjunction with purity values and top bottom ratios based on both Brix and purity are indicated as fairly reliable for determining maturity.

2. Effect of arrowing

Current year results confirmed the findings of the previous year that under Coimbatore conditions (1) arrowed canes register improvement in juice quality, in some cases for about two months after the short blade stage, and (2) that non-arrowed canes show considerable increase in weight long after the arrowed canes of the same variety have ceased to add weight.

3. Fibre in canes

Periodic fibre determinations showed that, whereas in arrowed canes the tops indicated an increase in fibre content with the advance of ripening, this was much less in evidence in the non-arrowed canes of the same variety. Secondly, whereas at about the arrowing time for canes, both arrowed and non-arrowed canes contain less fibre in the tops than in the bottoms, the arrowed canes soon register a greater amount of fibre in the tops than in the bottoms.

4. Root Studies

A method was developed to ascertain the predilections of canes in the matter of soil types. This is done by inducting a definite number of roots from the same root zone or shoot and leading

an equal number of these into earthen pots containing different soil types (Plate IV, figs. 1 and 2). The roots are allowed to grow in these pots and after a definite period the roots from each pot are washed, studied and weighed (Plate IV, fig. 3). Certain of the results obtained are in accordance with the known preferences of the canes under field conditions.

Attempts to secure on a piece of cloth buried in the soil a pattern of the active root regions of sugarcanes has given promising results, and a special plot has been laid out to test the method. Co. 421 and Burma *S. spontaneum* showed rapid and extensive root development with this method.

The Botany Assistant, Mr. R. Thomas, has been able to secure under controlled conditions an abundant development of root hairs for comparative studies of varieties.

5. Sports through bud mutilation

Mr. R. Thomas also succeeded in obtaining about half a dozen bud sports from Co. 213 by mutilating and injuring the buds before planting.

6. Types of *S. sponteneum*

Certain of the Bihar types of *S. spontaneum* (collected by Mr. Thomas) showed high sucroses and purities in the periodic routine analyses. The collections at the station have been augmented by two forms from Assam and an equal number from Mid-Asia through the Lenin Academy. The latter are reported to be capable of withstanding very low temperatures and that for comparatively long periods.

V. WORK AT THE KARNAL SUB-STATION *

1. General growth conditions during the year

The rainfall during the year was 43·60 inches as against the average of 30 inches for the tract and was, besides, well distributed. The total absence of rains during May and June was somewhat unusual. The summer was milder than in previous years during April but of about average severity during May and June. There was practically no frost. There were no cyclonic winds, but considerable lodging was recorded because of the exceptionally good growth from the heavy rains which lodged the crop even with moderate winds. There were no major diseases and practically no *Pyrilla*.

*The work described in this section is financed by the Imperial Council of Agricultural Research.

Method to ascertain soil types suited to different sugarcane varieties.

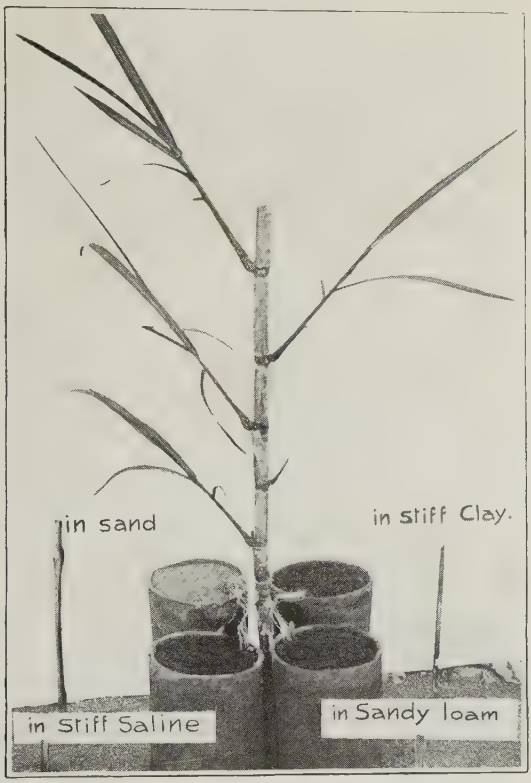

Fig. 1.

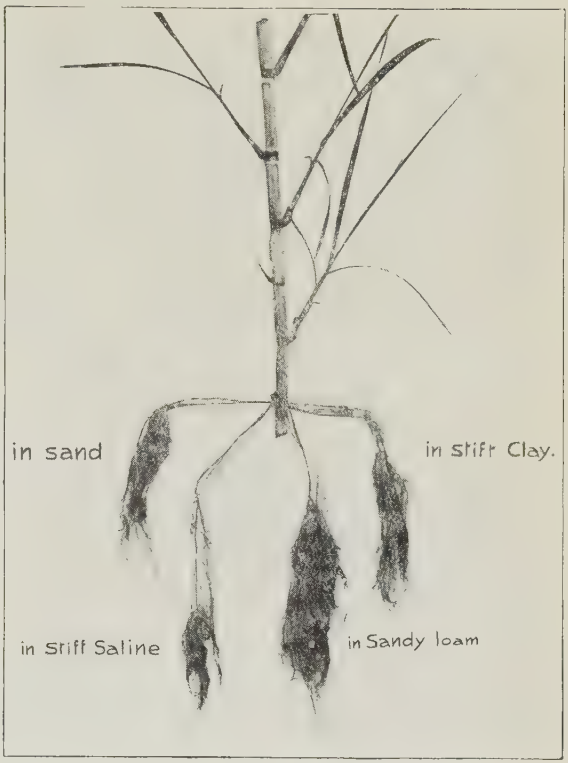

Fig. 2.

POOVAN.

Sand. Sandy loam. Stiff clay. Stiff saline.

One Month Old.

Fig. 3.

Dry weight in grams—0.8 1.0 2.1 0.6

Fig. 1. An equal number of roots from the same plant growing in pots containing different soils.
Fig. 2. Roots of above washed a month after setting up.
Fig. 3. *Poovan* roots showing growth differences in the various soils.

2. Seedlings under test from early Nursery Stage

About 5,000 hybrid seedlings, with Co. 213 as mother and Co. 244 and Co. 285 as male parents, were grown for a full year. Most of them are distinctly superior to the standards in juice quality and some possess satisfactory growth vigour as well. The breeding for Karnal will need to aim at still greater vegetative vigour than in the present lot. Including the 5,000 seedlings imported into Karnal in seed pans during the year, the crop at Karnal represented an original block of over 22,000 hybrids.

3. Studies in regular Test Plots

The number of seedlings which had reached the stage for regular studies during the year was 43, consisting of 29 Coimbatore productions and fourteen seedlings grown at Karnal from early nursery stages.

Cane germination.—Periodic germination counts of the same varieties in the irrigated and rain-fed plots showed interesting differences amongst them. While in the irrigated plot Co. 213, Co. 243 and Co. 341 were distinctly superior to Co. 285, the latter easily led in the unirrigated plot. Co. 331 showed satisfactory germination in all the plots.

Summer drought.—On the basis of shoot weighments the undermentioned seedlings (arranged in descending order) were found to have stood the summer drought satisfactorily :—

Co. K. 22, Co. 356, Co. 312, Co. 341 and Co. 331.

Lodging from winds.—The rapid growth in July and subsequent months from the high rainfall would appear to have made the canes somewhat brittle, causing snapping when the crop was propped up. In spite of this, Co. 213, Co. 285, Co. 313, Co. 331, Co. 341 and Co. 421 came out best, while Co. 244 and Co. 301 fared worst. Whereas Co. 244 lodged and snapped badly in the canal-irrigated plot, the same variety in the unirrigated *barani* plot stood well. It would, therefore, appear not desirable to encourage much vegetative growth in Co. 244 through heavy irrigation or manuring.

Borers.—Through the kindness of the Government Entomologist, Punjab, certain varieties in both the rain-fed and canal-irrigated plots were studied for borer infestation. The highest was 11·5 per cent in the irrigated plot and 19·8 per cent in the unirrigated. Co. 205 was most attacked and Co. 331 the least.

Certain of the varieties were available in both the rain-fed and canal-irrigated plots. Of these, Co. 281 and Co. 356 were least attacked in both plots and Co. 243 was the worst sufferer. These studies have shown that popular canes like Co. 281, Co. 285, Co. 331 and Co. 356 were fairly resistant to borer attack during the year. Another popular cane, Co. 312, showed comparatively less infestation in the unirrigated plot.

Root-systems.—The programmed root dissections during July had to be stopped half way on account of unexpected continued wet weather. Co. 285, Co. 331, Co. 341 and Co. 356 showed root-systems six feet deep, Co. 301, Co. 312 and Co. 318 five feet deep and Co. 213, Co. 244, Co. 270, Co. 281 and Co. 300 four feet deep towards the beginning of winter.

Yields of cane and gur.—Periodic weights of cane and *gur* of ten whole rows during the months of November, January and February showed interesting differences in the behaviour of the canes. Whereas certain canes like Co. 313 and Co. 356 showed steady increase in both yields of cane and *gur*, Co. 312 and Co. 270 showed a drop after January, though the Brix readings registered steady improvement in juice quality in both of them. This drop was found to be due to the death of certain of the canes between November and February. Such studies starting from November and continued every month up to the fag end of the cane crushing season in the tract should give useful indications as to the most profitable time for harvesting the different varieties. Co. 213, Co. 285, Co. 313, Co. 341, Co. 349 and Co. 356 all showed a steady increase in *gur* from November to February.

4. *Barani* Trials

Under unirrigated conditions Co. 312 stood first in shoot weight in July (at the beginning of rains) followed by Co. 356, Co. 244 and Co. 213 in descending order. Towards the onset of winter Co. 312 continued to lead in shoot weight and weight of millable canes. Between the two weighments Co. 341 had worked up to second rank with Co. 356 as the third in weight of millable canes.

VI. DISTRIBUTIONS FROM THE COIMBATORE STATION

1. As seeds

Preserved seeds of P. O. J. 2725×Co. 281 and P. O. J. 2725 ×Co. 301 were sent to Natal, and of Saretha, Kansar and Lalri to Mauritius. Seeds of Co. 313×Co. 285, Co. 349×Co. 285, Co. 354 ×Co. 285 and Co. 354×Co. 331 were sent to Shahjahanpur and of Co. 312×Co. 285 to Lyallpur.

2. As seedlings

About 5,000 seedlings of Co. 312 and Co. 313 crossed with Co. 285 (father) were despatched to the Sub-station at Karnal. No seedlings were sent to Shahjahanpur as that station has now decided to import only seeds and germinate them at Shahjahanpur.

3. As canes

About 250 packets containing over forty Coimbatore canes were distributed to thirty places within Indian limits. The foreign consignments consisted of thirty-four separate packets and were sent

to Australia, Portuguese East Africa, Egypt, Saint Denis, Ceylon, Trinidad and Washington.

VII. PERFORMANCE OF COIMBATORE CANES

1. In India

Among the canes bred at the Thick Cane Area by Mr. N. L. Dutt, Co. 419 and Co. 421 are giving very good results in the testing stations, the former mainly in tropical and the latter in sub-tropical areas. Co. 419 recorded much higher yields than the well known P. O. J. 2878 at Padegaon in the Bombay Presidency and proved superior both to Striped Mauritius and the local Pyinmana Red in Burma. Co. 421 showed itself the leading cane at the Karnal Sub-station and is in favour in the North Indian Stations.

Co. 213 showed marked resistance to frost in Sind, as also Co. 313, Co. 281 and Co. 270. The older thick canes introduced into Sind have not been able to bear the severe frost there. Co. 223 in the Punjab has again shown good ratooning characteristics. Co. 312 has proved superior to the older Coimbatore seedlings both in the Sarada and the North-East Circles of the United Provinces. Co. 331 is one of the new canes which is being developed in the United Provinces for wide cultivation under tube well irrigation as a late season cane. Co. 244 continues to be useful under indifferent conditions in South-East Punjab and the United Provinces.

2. In Foreign Countries

Besides Co. 281 and Co. 290 which have already established themselves in foreign countries, two other Coimbatore seedlings which are coming into favour are Co. 270 and Co. 301 ; the latter has recently been released for commercial planting in Natal.

Certain Coimbatore seedlings, Co. 290 and others, are attracting attention in Australia as fodder canes and are replacing the older Japanese types. The canes are chopped fine (1/8 inch to 3/8 inch lengths), mixed with bran and molasses and fed. This is perhaps worth trial in India as an alternative and valuable fodder material.

VIII. PARENTAGE OF COIMBATORE SEEDLINGS

Co. 439	P. O. J. 2727 × Co. 408.
Co. 440	Co. 360 (General Collection) ; likely father Co. 361.
Co. 520	Co. 349 × Co. 281.
Co. 521	Co. 349 × Co. 312.
Co. 522	
Co. 523	
Co. 524	
Co. 525	
Co. 526	
Co. 527	
Co. 528	Co. 213 × Co. 331.
Co. 529	Co. 213 × Co. 508.
Co. 530	
Co. 531	
Co. 532	
Co. 533	Co. 349 × P.O.J. 2878.

IX. REPORT OF THE SECOND CANE BREEDING OFFICER

(N. L. Dutt, M.Sc.)

1. Sugarcane Breeding (Mainly Tropical Types)

Breeding programme.—The outstanding crosses effected during the year were those in which Co. 419 and Co. 421 were utilized as parents. In all sixty different crosses were made, out of which the following are the more important ones :—

Co. 421 × Co. 419.
Co. 421 × Co. 290.
Co. 421 × Co. 413.
Co. 419 × Co. 413.
Co. 360 × Co. 290.

In the breeding of thick canes for the various parts of India the stage has now been reached when, barring the experimental crosses, the breeding of economic types is largely restricted to crosses between the various Coimbatore canes themselves.

The choice of P. O. J. 2878, Co. 290 and a few other canes as parents has been justified by the performance of Co. 419 and Co. 421 already mentioned. Judging from reports received they might be expected to replace some of the extant varieties in at least a few of the more important tracts. These canes in their turn are yielding seedlings of very satisfactory vigour and it is proposed to utilize them extensively as parents.

Seedling plots.—The number of seedlings raised and transplanted was the largest ever attempted at the Thick Cane Area and the nursery plot was extended to accommodate the extra number. Over 200,000 seedlings were germinated in seed pans and half this number transplanted into beds. A feature of this year's seedling plot was the excellent vigour in quite a number of crosses. In the field nursery the seedlings of Co. 408 × Co. 415, Co. 417 × P. 1587 and Co. 420 × Co. 244 were particularly striking.

Test plots.—Two hundred and eleven seedlings were dealt with in the various test plots and, of these, 89 were selected for further tests.

Selection of economic types.—After studying growth and habit characters as also sucrose and purity figures, 440 seedlings were selected from the field nursery. Only two seedlings were raised to the status of "Co." canes during the year. These are Co. 439 and Co. 440 whose parentages are given elsewhere in the report. Of the two, Co. 440 is a relatively early ripener.

Type of seedlings yielded by different crosses.—Twenty-nine crosses were studied in detail for the type of seedlings resulting from them. One hundred seedlings were taken from each cross, and Brix, weight of canes and number of tillers recorded. The

FIG. 1.

P. O. J. 2878 and Co. 419 at the Agricultural Research Station, Anakapalle (Madras Presidency).

(Photograph through the courtesy of the Superintendent.)

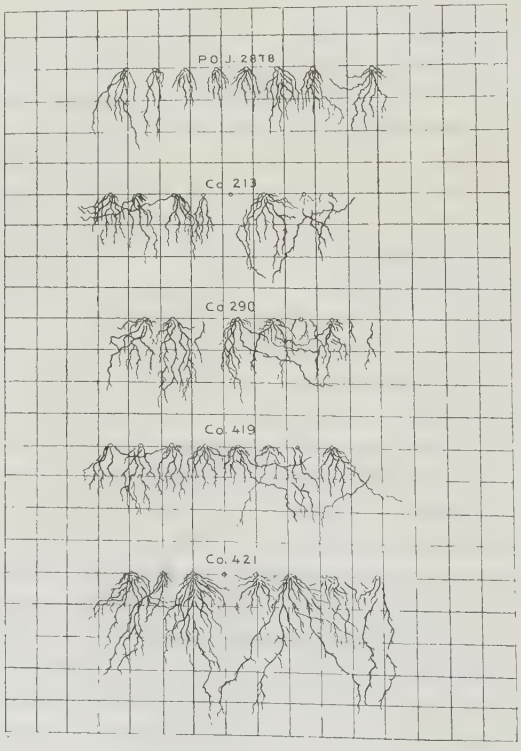

FIG. 2.

Root-systems of Co. 419 and Co. 421 (12 weeks from planting) compared with those of three standard varieties.

percentage of desirable seedlings yielded by the following crosses was higher than the rest :—

P. O. J. 2725 × Co. 290.	P. O. J. 2727 × Co. 243.
Co. 419 × Co. 408	P. O. J. 2878 × Co. 281

2. Research

Flowering habits of certain forms of Saccharum.—Observations on floral characters were continued and twenty more varieties taken up during the season. The times of opening and closing of flowers did not differ much from those observed last season. While there is difference in the time of anther dehiscence in *Glagah*, Co. 285 and *S. officinarum* between (*i*) dry windy mornings, which hastened and (*ii*) cool dewy mornings, which retarded flowering (anthesis), *S. spontaneum* (Coimbatore) is affected only slightly by change of weather.

The availability of healthy pollen with reference to colour of anther was studied in some detail. Paintings of the anthers before and after dehiscence were recorded in nineteen varieties which almost covers the range of colours met with in the genus *Saccharum*.

Pollen studies.—A variation in the method of storage of pollen was tried. Spikelets, in which the anthers were just protruding, were brought to the laboratory and kept at a temperature ranging from 7° to 10° C. Pollen of Co. 432 thus kept gave 9·3 per cent germination with fairly long tubes after eight days' preservation. One distinct advantage in this method is the absence of "caking".

The interesting observations on the occurrence of four generative nuclei in certain forms of *Saccharum* were taken up with reference to a few more sugarcane varieties. Black Cheribon and Sealy seedling were found to show four generative nuclei as also Karia and Kajla, but not Hmawbi Black.

Vernalization.—No significant results were obtained in this experiment as both the control and treated canes flowered at the same time.

Root studies.—The monthly root dissections were continued in Co. 213, Co. 290, Co. 419, Co. 421 and P. O. J. 2878 and the depth and lateral spread of the same recorded. The roots were then dried and weighed. Co. 421 showed the best root-system both as regards depth and lateral spread as also in weight throughout the year in all the twelve dissections. In Plate V, fig. 2, the root-systems of these varieties are shown twelve weeks after planting.

Germination in thick cane seeds.—With a view to ascertain the relative percentages of germination and vigour of seedlings from pedicelled and sessile spikelets, 500 pedicelled and 500 sessile spikelets were separated from the fluff of the following canes and sown

separately : *S. spontaneum*, Co. 205, Co. 421×Co. 285, Co. 419×Co. 285 and Kaludai Boothan×Co. 417. Seeds from sessile spikelets showed higher percentages and greater vigour in the seedlings.

Variations in the size of chloroplasts.—A preliminary study of the size of chloroplasts in the leaves of various species of *Saccharum* was taken up with a view to ascertain its classificatory value, if any. Slight differences were noticed in the size of chloroplasts in the species studied. An interesting observation made was that the size of chloroplasts in the leaves and sheaths of young seedlings was much bigger than that in the leaves and sheaths of fully grown plants, in certain cases about twice the size.

Study of sterility.—During the course of the work it was noticed that certain varieties, *viz.*, P. O. J. 2714, Tanna and a few others, did not set seed. With a view to ascertain if irregularities in megasporogenesis are responsible for sterility in the above mentioned varieties spikelets of various ages were fixed and sectioned. Certain stages in the development of the egg-mother-cell have been obtained in P. O. J. 2714. The work is in progress.

Mosaic and bristles.—About a dozen varieties were examined for the number and disposition of unicellular bristles on the under-surface of the leaves. Co. 213 and Co. 214 are both characterised by a somewhat smaller number of bristles and yet the former is very susceptible and the latter immune to mosaic. Similarly P. O. J. 2878, which is highly resistant, has only a somewhat smaller number of bristles like Co. 214. It was also noticed that the bristles in these immune varieties do not cover the stomata.

X. MISCELLANEOUS

About a dozen canes were imported from overseas, *viz.*, Natal, Barbados and Egypt. The consignment from Egypt contained the interesting Pharaoh cane.

The year was a particularly dry one with almost a total failure of the south-west monsoon which caused a considerable amount of hardship. But the cane crop was not allowed to suffer.

I delivered (1) the Maharajah of Travancore Curzon Lectures under the auspices of the Madras University and (2) the Maharajah Sayaji Rao III Golden Jubilee Memorial Lecture at Baroda.

The visitors during the year included Mr. C. J. Olivier from Portuguese East Africa, Mr. Ibrahim Mahdavi, Agricultural Officer, Persia, Mr. H. H. Dodds, Director, Sugar Experiment Stations, Natal, and Rao Bahadur B. Viswanath, Officiating Director, Imperial Agricultural Research Institute, New Delhi.

XI. PROGRAMME OF WORK FOR 1936-37

The breeding will be continued with the object of effecting further improvements in various directions.

Studies will be continued on the causes of sterility in sugarcane flowers, maturity determination and root development.

Cyto-genetic and morphological studies of the genus *Saccharum* will be continued and extended.

XII. PUBLICATIONS

1. Dutt, N. L., Hussainy, S. A., and Krishnaswamy, M. K. . . . A Note on the Breeding of Sugarcane Varieties Resistant to Mosaic. *Proc. Ind. Acad. Sci.*, Vol. III, No. 6, Sec. B, 1936.

2. Janaki Ammal, Dr. E. K. Cyto-genetic Analysis of *Saccharum spontaneum* L. 1—Chromosome Studies in some Indian Forms. *Ind. Jour. Agri. Sci.*, Vol. VI, Part 1, February 1936.

3. Janaki Ammal, Dr. E. K. and Singh, T. S. N. . Cyto-genetic Analysis of *Saccharum spontaneum* L. 2—A Type from Burma. *Ind. Jour. Agri. Sci.*, Vol. VI, Part 1, February 1936.

4. Venkatraman, Rao Bahadur T. S. . . . Methods of Selecting Sugarcane Seedlings (as adopted at Coimbatore). *Agri. and Live-stock in India*, Vol. V, Part VI, p. 650.

5. Venkatraman, Rao Bahadur T. S. . . . A Visit to the Australian Sugar Industry and to Java. *Agri. and Live-stock in India*, Vol. VI, Part III, May 1936.

6. Venkatraman, Rao Bahadur T. S. . . . Report on the Development of Sugar-Cane Cultivation in the Nizamsagar Canal Area. (Published as Bulletin No. 9 of the Nizam's Agricultural Department, Hyderabad, Deccan.)

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(B. Viswa Nath, F.I.C.)

I. CHARGE

I held charge of the Section throughout the year. Towards the end of October 1935, I was transferred to Delhi to take charge of the post of the Director from Dr. F. J. F. Shaw on the 26th October, 1935, in addition to my own duties as Imperial Agricultural Chemist. Mr. J. N. Mukerji, Assistant Agricultural Chemist, was in charge of the current work at Pusa and of the post-graduate students. Mr. N. V. Joshi, Assistant Agricultural Bacteriologist, was in charge of the work on micro-biology. He was on leave for 12 days from 14th to 25th October in continuation of the Puja holidays.

The activities of the Section during the year were mainly in the direction of checking and packing of stores for the move to Delhi. Several pieces of apparatus and equipment had to be dismantled, cleaned and the component parts carefully marked and numbered to facilitate re-assemblage at Delhi. Every other work except that of the post-graduate students and that relating to the completion of the problems on hand and routine was suspended.

II. POST-GRADUATE WORK

Messrs. Narendra Kumar Das, M.Sc., and K. Swaminathan, M.Sc., successfully completed their two years' training. The former immediately after his completion of course was appointed as a Research Assistant to the Agricultural Chemist, Bihar, and the latter has recently taken up an appointment as Chemist in the malting scheme of work in the Marketing Section of the Imperial Council of Agricultural Research.

Messrs. K. V. S. Satyanarayana, C. Parthasarathi, M. A. Idnani and Serajuddin Sadiqbhoi entered into their second year's programme of work. Mr. S. C. Roy who joined the course in November 1934 left it without completing in June 1935, in order to join the Rowett Research Institute at Aberdeen.

Messrs. P. Mukerji from the United Provinces, T. P. Sundram from Travancore State, A. T. Sanyal from Bengal and I. D. Dham from the Punjab were admitted as post-graduate students in November 1935. Mr. I. D. Dham left the course soon after joining

One Dairy Diploma student had a short course of lectures and practical work in dairy bacteriology.

Mr. S. V. Ramanayya, B.A., B.Ed., Sugar Chemist, Co-operative Sugar Factory, Etikoppaka, Vizagapatam District, worked on the chemistry of sulphitation process as applied to coloured canes, for three months from 3rd September to 29th November 1935, and completed his work for a thesis for the M.Sc. degree.

Mr. V. S. Abhyankar, Research Assistant from Agricultural Institute, Poona, worked for three months, from 10th January to 31st March 1936, on the organisms in wheat and rice roots.

Mr. T. Varahalu was awarded the M.Sc. degree of the Madras University for his work on the Physics and Chemistry of *Gur* Manufacture, done under my guidance.

III. RESEARCH AND INVESTIGATIONS

1. Soils

Delhi soils.—A study of the soil profiles of one foot layer down to 15 feet and another down to 11 feet from the site of the Imperial Agricultural Research Institute, New Delhi, was taken up. The chemical and mechanical composition of soil layers of the 15 feet profile were determined and a study of the clay complex of the different layers was in progress.

The mechanical analyses of these soil profiles were carried out by the three different methods of pre-treatment—(1) boiling, (2) sodium clay method and (3) the International. The clay, silt and sand fractions of the samples have been collected and preserved for further study. As would be expected, the clay fraction increased by the two latter methods with a corresponding reduction in the coarse fractions. A layer of lime nodules occurs from 4 feet to 15 feet depth and lime is present both as carbonate and silicate. The composition of the clay fractions at different depths varied as shown below :—

Silica	35—53	per cent
Iron Oxide (Fe_2O_3)	7—11	,,
Alumina (Al_2O_3)	14—22	,,
Lime (CaO)	2—20	,,
Magnesia (MgO)	2·5 —4	,,
Potash (K_2O)	1·5 —2·75	,,
Phosphoric anhydride (P_2O_5)	0·05—0·12	,,

Magnesia and potash are constant in quantity in all the depths down to 15 feet. The upper layers are richer in phosphoric acid and silica.

Acid soils and lime requirements.—The investigation on soil acidity and lime requirement was extended to the study of soil and crop characteristics. In the previous season it was observed that in pot experiments the effect of varying doses of lime applied in 1932 continued till the barley crop of 1934-35 winter season, and that the yield of barley increased gradually over control up to

additions of lime equivalent to twice the lime requirement and then gradually fell down. Work on these soils during the year showed that the moisture equivalent decreases with the decrease in soil acidity ($\frac{2}{3}$ application of lime requirement) and then begins to increase with increasing lime treatment.

Acid soils and nitrification.—The relative merits of calcium carbonate and sodium carbonate as correctives for soil acidity were studied individually and in mixture. The latter resulted in better nitrification. Addition of phosphate did not increase total nitrate formed but increased the rate of nitrification.

Photo-nitrification in soils.—A further series of experiments to find out the effect of sunlight and ultra-violet light from a mercury vapour lamp on nitrification in acid and alkaline soils and in solutions were carried out using different nitrogenous substances. No evidence of the effect of light either in initiating or assisting nitrification was found. On the other hand, it was observed that direct exposure to strong sunlight or ultra-violet light inhibited nitrification and reduced nitrates.

Micro-organisms in stored soils.—Samples of soils collected at Pusa in 1906 and stored were examined micro-biologically to know what organisms survived during storage. Comparative studies were made on soil samples collected from the same fields in 1935.

The numbers of bacteria in the 1906 samples were less than in the 1935 samples. This decrease varied from 16 to 50 per cent, depending on the medium used. Fungi are present in greater numbers in 1906 samples than in 1935 samples.

Spore-forming organisms alone appear to have survived in 1906 samples ; the activity of urea splitting and ammonifying organisms does not, however, appear to have diminished. The carbon-dioxide forming capacity also of the 1906 samples of soils appears to be unaffected. Nitrifying organisms seemed to have either disappeared or become completely inactive and there was no evidence of azotobacter cells.

2. Fertilizers and Crops

Manuring and cropping on vertical distribution of carbonates and phosphates in the calcareous soils of Pusa.—Examination of three-inch deep soil borings down to a depth of five feet indicated two zones of maximum carbonate concentration with one of minimum concentration lying between the two. This was so in all the manured and cropped plots. The fallow plot on the other hand showed gradually increasing carbonate concentration with depth. The phosphate concentration tended to vary inversely as the carbonate concentration.

Khudada phosphates.—Investigation on the possibility of solubilisation of apatite known as Khudada phosphate was carried out, and it was found that sulphuric acid, if added in sufficient amount to dissolve the iron oxide and insoluble phosphates, can make the phosphate soluble. Lesser amount of sulphuric acid does not effect solubilisation to any greater extent than 10 per cent of the insoluble phosphate. The higher amount of acid required makes the solubilisation of phosphate into superphosphate, an uneconomic proposition. It is suggested that the excess of acid could be added and the extra acid utilised to dissolve bonemeal by the addition of bonemeal to apatite in order to convert the mixture into superphosphate economically.

In previous years it has been shown from laboratory experiments that the yield of wheat after applying sann-hemp tops alone is equal to that when the whole of the sann-hemp plant is buried in the soil. The former plan gives the cultivator the advantage of fibre from the sann-hemp. The results of large-scale experiments carried in field have shown that while the yields of wheat from sann-hemp whole plants *versus* tops alone were the same, the yield of fibre from the stems remaining after using tops as manure was 500 to 650 lb. per acre.

A study of the top-bottom ratios of sugarcane grown in Pusa Farm has shown that in healthy canes the top-bottom ratios increased as the canes matured and as the sucrose content and purity of the juice increased, and that there was a direct relationship between the top-bottom ratio and the sucrose content and purity of the juice, but in case of canes which were either lodged or attacked with borers, and in canes which were both lodged and attacked with borers, no such relationship between the top-bottom ratio and sucrose content and purity of the juice could be observed. In case of canes treated with different manures which, however, were not attacked with borers or lodged no corelation between the top-bottom ratios and sucrose content and purity of juice could be established.

The work on the movement of nicotine in tobacco-tomato grafts, which was reported last year, was continued. Periodical (fortnightly) examinations of the different parts of the tobacco-tomato and tomato-tobacco grafts made by the Imperial Economic Botanist were carried out with respect to their nicotine content. It has been observed that nicotine migrates from the tobacco stock into the tomato scion but not from the tobacco scion into the tomato stock. Further work on this was carried out and examination of over 200 samples confirmed the interesting observation made above.

A study of an organism associated with mosaic in different plants of tomato, lady's finger, etc., was carried out, and it was observed that cultures of the organism could induce mosaic on

inoculation on many occasions and the organism could dissociate into several kinds of forms including one filterable stage which might perhaps be identical with the virus which is assumed by many scientists to be the cause of the mosaic.

3. Investigations on Agricultural Produce

Improvements in the process of gur *and sugar manufacture.*—A certain amount of work was carried out to devise rapid methods for filtering sugarcane juice scums, with a view to accelerate the process of *gur* and sugar making by the open pan method.

The canes responsible for the production of brown coloured sugar from Purple Mauritius canes by the sulphitation process were investigated and an improved method to remove the defect was developed and tested with satisfactory results. It consists in heavy liming and deliming with alum to remove the anthocyanin pigments which would otherwise persist to the final stage in manufacture.

Malting tests with barley.—Eight types (T_1, T_2, T_{12}, T_{20}, T_{21}, T_{22},T_{23}, and R_1) of 1935 crop of barley grown at Pusa by the Imperial Economic Botanist were submitted to malting tests in the winter of 1935-36. Compared with the results of similar tests with the 1934 crop, these samples had a longer drying and at a lower temperature which probably explains for the higher extractives. From a consideration of all the data on barleys and the malts prepared from them, types T_{22}, T_{12}, R_1, T_{23} and T_{21} are good malting barleys, while T_1, T_2 and T_{20} do not make acceptable malts.

IV. GENERAL CONSULTATIVE AND ANALYTICAL WORK

The following samples were analysed and reported upon during the year :—

Soils	9
Manures and fertilisers	20
Oil-seeds	58
Sugarcane	356
Foodstuffs and fodders	10
Minerals and Salt	6
Ganja	3
Tobacco	20
Water	4
Oil	1
Miscellaneous	3

Among samples examined mention may be made of the following on account of their scientific or economic interest.

Pohli oil.—The Director of Agriculture, North-West Frontier Province, sent one sample of *pohli* oil (oil from wild safflower *Carthamus oxycantha*) for analysis and report on its economic use and market in foreign countries. The oil was found to have the following physical and chemical constants :—

Specific gravity at 15° C.	0·924
Iodine value	143·3
Saponification value	168·6
Refractive index	1·468
Optical activity	*Nil*

The oil was easily saponifiable and its high iodine value and specific gravity indicated it to be a drying oil. It is from this source that *roghan* is manufactured which is extensively used for making Afridi waxcloth and also for making waterproof patterns on cloth. It may also be used in paint as a substitute for linseed oil. The principal outlet for this oil in the Punjab at present seems to be its use as a food and as an adulterant for ghee. As safflower oil forms an ingredient of Macassar hair oil, there is the possibility of its use as such.

Linseed cake.—In April last, a number of Pusa Dairy cattle became sick by taking a mixed fodder containing oats, pulse, linseed cake and groundnut cake. Examinations of the cattle feed (groundnut cake, linseed cake and the mixed fodder) showed the presence of an appreciable amount of hydrocyanic acid in the linseed cake and a slight amount in the mixed fodder. The groundnut cake was found to be free from hydrocyanic acid. The linseed cake was suspected to be a product of cold extraction ; it was, therefore, steamed for an hour in order to expel any free hydrocyanic acid, and to destroy the enzyme responsible for the liberation of hydrocyanic acid by the hydrolysis of the cyanogenetic glucoside. The steaming had the desired effect, as subsequent steeping in water did not give rise to the production of free hydrocyanic acid in the steamed cake as was the case with the sample previous to steaming.

Waste water from sugar factory.—A sample of waste water received from the Manager, Ryam Sugar Factory, through the Sugarcane Mycologist, which was being utilised by the factory for irrigating sugarcane with deteriorating effect on the crop was found to contain an abnormally high organic acid.

Canes damaged by borers.—Fifty-four samples of normal and borer-damaged canes were analysed for the Imperial Entomologist. Judging from the composition of the juice it would appear, as observed last year, that top (shoot) and stem borers are decidedly more detrimental than the root borer. The root borer hardly affects the composition of the juice.

V. PUBLICATIONS

1. N. V. Joshi and C. S. Rama Ayyar . . An aroma producing lactic acid organism isolated from Indian Dairy Products. (Accepted for publication in the *Ind. Jour. of Animal Husb. and Dairying.*)

2. N. V. Joshi and S. C. Dutta . . . Studies in the dissociation of *Bacillus cereus,* an organism associated with plants affected with mosaic disease. (Accepted for publication in the *Ind. Jour. Agri. Sci.*)

REPORT OF THE IMPERIAL MYCOLOGIST

(L. D. Galloway, M.A.)

(1) MYCOLOGICAL SECTION, PUSA

I. ADMINISTRATION

Mr. Galloway held charge of the Section throughout the year.

Work at Pusa during the year under review has been considerably handicapped. The laboratory accommodation improvised after the 1934 earthquake has been getting steadily worse and has made pure culture work difficult. Moreover, the last months have been completely taken up with packing and other preparations for the move to the new Institute at Delhi.

II. TRAINING

Mr. S. C. Chowdhury, B.Sc. (Ag.), who was admitted on January 2nd, 1935, continued his post-graduate studies.

Mr. T. B. Lal Kulsherestha, B.Sc. (Ag.), joined the Section for training from November 8th, 1935.

III. DISEASES OF CROP PLANTS

1. Wheat

Loose smut.—Hot water treatment again gave good control of loose smut. It was observed, however, that wheat seed given hot water treatment and subsequently stored suffered a more rapid loss in viability than untreated grain. This appears to be connected with the physical effects of the treatment, *e.g.*, removal of wax, cracking of endosperm, etc., and not in any way due to increased liability to attack by moulds. Hot water treatment should therefore only be applied immediately before sowing.

Bunt.—Seed treatment with fungicides reduced but did not entirely prevent bunt, and, as mentioned in last year's report, there is evidence that infection is soil-borne as well as seed-borne. An experiment is in progress to test the efficacy of certain rotations in soil infected with *Tilletia indica* Mitra.

Measurement of a large number of healthy and bunted ears at Karnal showed that bunt infection reduces both the length of ear and the number of spikelets.

Bunt does not develop under Pusa conditions, even in infected soil brought from Karnal and given additional infection at the time of sowing.

Rust.—The dates on which rust was first observed at Pusa this year were December 23rd for orange rust, January 20th for yellow rust, and February 9th for black rust.

Aeroscope slides were exposed as in previous years, for Dr. K. C. Mehta in connection with his rust research scheme. In addition, a Fieldman was sent on tour for nine weeks to make a rust survey in connection with this work.

Black Point.—An examination of wheat seed affected with "black point" showed that 75 per cent of the seed gave rise to *Helminthosporium sativum* P. K. & B. This agrees with last year's results. Affected seed showed poor germination in soil and was readily attacked by foot and root-rots.

Foot-rot.—A small experiment was carried out to test the value of seed treatments of wheat and barley sown in soil heavily infested with *Helminthosporium sativum*. Ceresan treatment gave some reduction of seedling deaths, but malachite green was not effective.

2. Oats

Smut.—Germination tests with smut spores of oats and barley stored at Pusa showed that even if kept at 20° C. the spores lose their viability between one season and the next unless kept in sealed glass tubes or similar air-tight containers. This explains the failure of certain infection experiments.

During the present season 101 oat types were treated with smut spores and germinated. The degree of susceptibility of the different types is being compared.

Foreign oat differentials again failed to do well at Pusa, but most have set seed when grown under Karnal conditions.

3. Barley

Sixty-eight barley types, after heavy artificial infection with smut, were sown to test their resistance. All showed fair germination, with the exception of those that were de-hulled, but they failed to develop sufficient smut. The varietal and fungicidal trials were therefore negative.

4. Maize

A leaf disease of *Zea Mays* caused by a species of *Colletotrichum* was observed at Pusa. A close morphological study together with cross-inoculation experiments, led to the conclusion that the causal organism is identical with *Colletotrichum graminicolum* (Ces.) Wilson occurring on *Sorghum*.

Another new disease observed on maize is a bacterial leaf-streak, which is still under investigation.

5. Tobacco

Work on "black shank" disease of tobacco was continued. One variety appears to show a promising resistance to attack by this disease, and seed has been provided so that a larger scale trial of this variety may be carried out in the Vizagapatam District where this disease occurs.

6. Potato

In July 1935 a tour was made by Dr. B. B. Mundkur to take observations on the incidence of virus and fungal diseases of potato at various hill stations. As soon as funds become available, it is hoped to establish a definite scheme of work on mycological and virus diseases of potato in India.

Some experiments were carried out on storage. Sulphur treatment, and wet and dry mercury treatments, all failed to check rotting in storage.

7. Piper betel

A series of experiments to obtain further information as to the cheapest and most efficient soil treatment against *Rhizoctonia solani* Kühn, failed to give satisfactory results owing to the poor development of the parasite.

8. Cinchona

The study of seedling diseases in the Darjeeling District was again taken up. The disease appears to be soil-borne, and there is some evidence that the heavy mortality in the seed-beds and the disease occurring in older seedlings after planting out may be due to the same cause. Little mycelium can be found in affected tissues, but from a large percentage of the diseased seedlings examined it has been found possible to isolate a species of *Diplodia* and it seems likely that this may be the causal organism.

A test is in progress to try the efficacy of watering the seed-beds with weak fungicidal solutions of "Kerol" and malachite green.

A *Gloeosporium* sp. has been isolated from brownish spots on the leaves of cinchona.

9. Sann-hemp

A *Colletotrichum* disease caused very severe mortality among sann-hemp seedlings in the Botanical Area. The causal organism has been identified as *Colletotrichum curvatum* Briant & Martyn, recorded in the West Indies, but not hitherto reported in India. It is an extremely virulent parasite, and a spore suspension sprayed upon the seedlings produces 100 per cent. deaths when the plants

are young, but is less effective later. Seed treatment gives some degree of control, and spraying gives considerable protection but has little power to arrest the disease.

10. Other hosts

Asparagus.—The disease of asparagus mentioned in last year's report has been identified as due to *Phoma asparagi* Sacc., which is a new record for India. A short account has been published of the morphology and systematy of this fungus.

Grape vine.—The *Coniella* recorded last year appears to be *Coniella diplodiella* (Speg.) Petr. & Syd.

Chillies.—An outbreak of bacterial wilt in the Botanical Area was checked by spraying.

Linseed.—The varieties and hybrids in the Botanical Area were heavily affected by rust, and observations were taken on varietal susceptibility.

Hemp.—Cannabis sativa seedlings in the Botanical Area were affected by *Pythium aphanidermatum* (Eds.) Fitz.

IV. MISCELLANEOUS

Soil fungi.—The preliminary survey of soil fungi has been continued, and a short account submitted for publication. *Penicillium* spp. and *Trichoderma* spp. were plentiful in the acid soils of the hills, though uncommon in the alkaline soils of the plains, where *Aspergillus* spp., and notably *Asp. nidulans* (Eidam.) Winter were predominant.

Estimation of phosphorus and potassium content of soils.—To find an alternative to the "*Asp. niger* method" of soil analysis, a number of soil fungi were tried, and *Asp. oryzae* (Ahlb.) Cohn. and *Rhizopus arrhizus* Fischer both proved susceptible to small changes of phosphorus and potassium content. These moulds may be grown on unsterilized soil cakes moistened with a nutrient solution lacking in the element tested for.

Soil sterilization.—Soil fungicidal treatments were tested for the protection of (*a*) potatoes (*b*) gram against *Rhizoctonia* attack. This work will be continued.

"*Agral*".—This proprietary substance proved an efficient spreader. Laboratory experiments to test whether it interfered with the toxic action of fungicides showed no such effect with the organic substances tried.

Systematic work.—Alternaria spp. from safflower, hibiscus, wheat, sesamum and potato were studied. The stimulation of the formation of the perfect stage of *Corticium rolfsii* (Sacc.) Curzi by onion-peptone broth was confirmed.

A comparative study of *Colletotrichum* spp. isolated from pulses was continued. It appears that in addition to *C. lindemuthianum* (Sacc. & Mag.) Br. & Cav. there are at least two more species. An isolation made from *Phaseolus radiatus* formed the *Glomerella* stage in culture and inoculation experiments carried out proved its pathogenicity. On the host the conidial stage of *C. lindemuthianum* type was formed but the genetic connection has yet to be proved. The isolations from *Phaseolus aconitifolius* appears to be *C. lindemuthianum*, while those from *Vigna catjang*, *Stizolobium* sp., *Dolichos lablab* and *Phaseolus mungo* have falcate spores and are quite different from *C. lindemuthianum*. On some of these hosts *C. lindemuthianum* is also recorded.

Colletotrichum sp. isolated from infected leaves and leaf-sheaths of *Panicum frumentaceum* was found to agree with the characters of *C. graminicolum* (Ces.) Wilson.

Work on oospore production in paired cultures of *Phytophthora* was continued.

On a species of *Delphinium* from Simla, a smut due to *Urocystis sorosporioides* Koernicke was recorded during the year.

A smut causing witches'-broom on *Vitis quadrangularis*, which had been named by M. O. P. Iyengar and M. J. Narasimhan *Schizonella colemani*, was carefully examined and found to be *Mycosyrinx arabica* (P. Henn.) Penzig.

Diseased sweet potatoes were collected at Karwar, Bombay Presidency. These had on their surface large, black sclerotia of *Rhizoctonia solani* Kühn and the fungus had caused a shrivelling and a dry rot of the fleshy roots.

Herbarium and cultures.—Many additions to the Herbarium have been collected in India or received from abroad, and further progress has been made with the classification of half-named specimens. Cultures have been supplied in response to requests from other workers in India.

Various.—The Section on plant diseases for the Review of Agricultural Operations 1933—35 was written, and a list of new plant diseases recorded was sent to the International Institute of Agriculture, Rome.

Specimens of plant diseases, and the services of a demonstrator were supplied to the Patna Agricultural Exhibition.

The Imperial Economic Botanist was supplied with soil temperature data extending over some years, and a number of microphotographs were taken at his request.

About eighty specimens were received for identification and advice was given in response to the usual miscellaneous enquiries.

V. PROGRAMME FOR 1936-37

The first part of the next annual period will necessarily be largely taken up with the move to Delhi and organisation of the new laboratory. The reasearch programme will include the following heads :—

1. Survey of plant diseases in the neighbourhood of Delhi.
2. Establishment of a central fungal culture collection for India.
3. Continuation of work on cereal rusts, bunts and smuts.
4. Leaf curl virus of tobacco.
5. Study of fruit diseases.
6. Tests of fungicides for sprays, seed treatment and soil disinfection.
7. Comparative study on *Colletotrichum* spp. on pulses.

VI. PUBLICATIONS

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Galloway, L. D. . . The Control of Fungal Parasites by the Plant. *Proc. Ind. Acad. Sci.* 1936, **3,** 493.

Mundkur, B. B. . . . The Resistance of American Cottons to *Fusarium* wilt in India. *Proc. Ind. Acad. Sci.* 1936, **3,** 498.

(2) SCHEME FOR RESEARCH ON MOISAC AND OTHER DISEASES OF SUGARCANE*

[B. L. Chona, Ph.D. (Lond.), D.I.C. (Lond.)]

I. ADMINISTRATION

Charge.—Mr. L. D. Galloway, Imperial Mycologist, held charge, in addition to his own duties, until 23rd March 1936, when Dr. B. L. Chona was appointed with the designation of Plant Pathologist for Sugarcane Diseases. There was no change in the remaining staff.

Owing to the approaching shift of the Institute to Delhi the progress of work was considerably hampered, especially for the last few months of the period under review.

II. RESEARCH

1. Mosaic Diseases of Sugarcane

Distribution

Mosaic has been observed for the first time on the following cane varieties :—

Cuttack Farm : Co. 326, Co. 331, Co. 349, Co. 350, Co. 352, Co. 353, Co. 356, P. O. J. 247 and P. O. J. 2878.†

Shahjahanpur : Co. 354†, 427†, 510†, 517†, Co. S. 17†, and Co. S. 119 †.

Musheri : Shakar Chiniya†.

Tonnage Experiment

The tonnage experiment at Pusa was carried out with Co. 213 on the same lines as in the previous seasons. Thirty-eight plots, each 5×56 yards, were laid out in adjacent pairs. The setts were planted eye to eye.

Germination was good in all the plots and there was no spread of mosaic to the healthy plots. Insect trouble was not much in evidence and there were no deaths from other causes. At the time of harvest two end-plots and also 3 yards of cane from each side were rejected to eliminate the border effect.

As the results of previous years had not shown any statistically significant differences in Brix, sucrose, glucose and purity it was decided not to have any chemical analyses done.

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* Financed by the Imperial Council of Agricultural Research.

† These varieties have not previously been reported for mosaic in India.

The yield of stripped cane in maunds (1 maund=82·28 lb.) is tabulated below : the mosaic rows showed 40 to 50 per cent mosaic infection.

	Healthy	Mosaic
	Mds.	Mds.
Total (18 plots)	474·95	432·63
Mean	26·39	24·04
Difference	2·35 or 8·9 per cent	

The mean difference in yield between the healthy and mosaic is 2·35 mds. which was found to be statistically significant, applying Student's " Z " test. (Z=·69, *i.e.*, 1 : 195 odds). This is in agreement with the previous years' results.

Owing to the transfer of the Institute to Delhi, further tonnage experiments are being discontinued at Pusa. Tonnage experiments on the same lines with a thick " Ponda " variety, E. K. 28 (locally known as Surkha Saharanpuri) have been started at Karnal.

Varietal Test

In view of the extreme desirability of an exact knowledge of the behaviour of different varieties as to their relative resistance or susceptibility to mosaic and some important fungal diseases, the following important varieties have been selected for trial :—

Co. 213, Co. 214, Co. 223, Co. 244, Co. 281, Co. 285, Co. 290, Co. 299, Co. 312, Co. 313, Co. 331, Co. 352, Co. 356, Co. 360, Co. 361, Co. 402, Co. 411, Co. 412, Co. 413, Co. 417, Co. 419 and Co. 421.

Seed setts of these varieties, very kindly supplied by the Sugarcane Expert, Coimbatore, have been planted at Karnal.

Properties of mosaic virus

Distribution within the cane.—Mosaic affected canes of Co. 213, Co. 313 and Saretha were cut into " 3 eye " setts. Setts from top, middle and bottom portions were planted separately to compare their germination and mosaic development. Five hundred setts of each variety derived from hundred canes were sown. The results obtained seem to tally with those of last year, *i.e.*, the percentage germination of the setts from the basal portions was the lowest and the incidence of mosaic was lowest in the plants from middle-portion setts.

Saretha, on the average, showed the highest number of mosaic affected shoots and Co. 213 the lowest ; Co. 313 occupied an intermediate position, the percentage of infected shoots being 83, 38 and 55 for Saretha, Co. 213 and Co. 313 respectively.

Treatment of setts.—One hundred setts from mosaic clumps were treated with each of the following and planted in the field :—

2 per cent salicylic acid (3 hours), 2 per cent potassium iodide (3 hours), 2 per cent " clensel oil " (30 minutes), Bordeaux mixture (5 : 5 : 50) 5½ hours, 2 per cent pyridine (3 hours), 2 per cent ammonium sulphate (6 hours), 0·01 per cent malachite green (3 hours), 2 per cent tannic acid (3 hours), hot water (60°—65° C for 1 hour) and cold water (usual temperature) 2 days' soaking.

The setts soaked in cold water were the first to germinate and the total percentage germination also was the highest. Those treated with hot water altogether failed to germinate. Treatment with salicylic acid decreased the mosaic incidence materially. Bordeaux mixture, as in last year's experiment, increased the incidence and intensity of mosaic to an appreciable extent.

Artificial transmission.—A very large number of inoculations were performed for various transmission experiments but the percentage of successful inoculations was disappointing and some of the results obtained were erratic. However from the data in hand the following tentative conclusions have been arrived at.

Thermal death point.—Mosaic leaf juice of Saretha, Co. 213, Co. 313, M. 16 and Red Mauritius were subjected to different temperatures and then inoculated on maize plants to test their infectivity.

Saretha mosaic juice heated at different temperatures and then inoculated on Saretha plants gave the following results :—

Treatment	No. of plants inoculated	Number infected	Percent infection
Untreated juice	10 (Saretha) . .	5	50
Juice heated at 42°C. (10 minutes)	10 „ . .	4	40
„ „ „ 45°C. („)	10 „ . .	1	10
„ „ „ 50°C. („)	10 „ . .	1	10

The table shows that the thermal-death-point of Saretha mosaic virus lies a little above 50°C. Experiments done earlier in the season with maize as test-plants had also revealed its thermal-death-point as at about 50°C.

Similar experiments with M. 16, Co. 313, Co. 213 and Red Mauritius on maize as test plants showed that heating at 50°C. does not produce any appreciable loss of infective power of M. 16 and Co. 313 mosaic virus. Further heating at 60°C. inactivated Co. 313 virus but M. 16 virus still retained some infective power

That of Co. 213 falls from 90 per cent infection to 60 per cent on heating to 40°C. and to 0 per cent at 45°C. showing thereby that the thermal-death-point of Co. 213 mosaic virus lies between 40°—45°C. Thermal-death-point figure obtained for Red Mauritius mosaic virus lies between 40° and 50°C.

Filtration.—Clear brown L_3 filtrate of mosaic juice is non-infective. Various sets of inoculations from time to time both on cane and maize have proved unsuccessful, while the control unfiltered juice showed normal infection.

This shows that the sugarcane mosaic virus cannot pass through the Chamberland filter (L_3) or that it is in too dilute a concentration to be infective. Experiments are being devised to reconcentrate the virus in the L_3 filtrate.

Even the filtrate from a Seitz filter is non-infective. The residue held back by the Seitz filter when removed with water and inoculated into maize plants produced typical mosaic mottling.

In one set of experiments juice was filtered just once through ordinary filter paper and was inoculated into batches of 10 maize plants. The filtrate still retained some greenish colour. It gave as high as 70 per cent infection while the unfiltered control mosaic juice gave 90 per cent infection.

In the previous experiment, if the mosaic leaf juice was filtered through the same filter paper again and again till the filtrate was clear amber-coloured it was found that such filtrate proved non-infectious on maize. But if any greenish tinge was left in the filtrate it proved infectious. These observations strongly suggest that the infective principle is closely associated with chlorophyll.

Acidity and alkalinity.—In one of the preliminary experiments the Seitz-filter residue was removed with buffered solutions adjusted at pH 6·0 and pH 7·0. These suspensions when tested for their activity on maize plants gave 20 per cent and 7·5 per cent infection respectively.

From this it would appear that a faintly acidic medium is more favourable for virus to maintain its infectivity. Further work along these lines is included in the future programme.

Centrifuging.—In the two sets of experiments carried out to see the effect of centrifuging, one at 2,500 r.p.m. and second at 1,500 r.p.m., both supernatant liquid and sediment (washed with distilled water) were tested for infection. In the first set Co. 213 plants were used for inoculations and in the second maize plants. In no case was any infection obtained with the sediment, while the supernatant liquid gave 20 per cent infection with cane and 67 per cent with maize, which is about normal.

Dilution.—Various dilutions ranging from undiluted to 1 : 1,000 of Saretha and Co. 213 mosaic leaf juice were made with distilled

water. These were tested for infection on maize. The results obtained are as given below :

Dilutions	Co. 213	Saretha
Undiluted	Not tested	100 per cent
1 : 10 dilution	73 per cent	36 ,,
1 : 50 ,,	33 ,,	Not tested
1 : 100 ,,	27 ,,	18 per cent
1 : 1000 ,,	0 ,,	0 ,,

The power of infection seems to fall rapidly when the juice is diluted to 1 : 10 and beyond.

The previous experience with Co. 213 as test-plant is that no infection takes place beyond 1 : 10 dilution.

Chemicals.—Co. 213 mosaic leaf juice was treated for 15 minutes with 10 per cent and 20 per cent alcohol, 5 per cent toluene, chloroform vapour (15 and 30 minutes), carbolic acid 1 per cent, and formaldehyde 1 per cent. and then tested for infectivity. With the exception of the last two the infective principle of the mosaic juice does not seem to be affected. On the other hand there is a slight indication that short exposure to chloroform vapour has some activating effect on the mosaic virus.

Longevity.—Mosaic leaf juice (Co. 213) stored at 0°C. was found to be infective even after 48 hours. But when the storage temperature ranged from 5°—7°C. the juice was found to have lost its infectivity completely, when tested after 48 hours' storage.

Mosaic leaves severed from the plant and stored under identical conditions (at 5°—7°C.) were found to contain active mosaic virus even after a lapse of 144 hours' storage.

Cross-inoculation : Different varieties of cane

Leaf juice of mosaic-affected Saretha, Uba, Co. 313 and M. 16 was inoculated into Co. 213 plants. In all the cases, except M. 16, typical mosaic symptoms developed. Failure of M. 16 virus to infect Co. 213 is in accordance with last year's results. This point, however, needs confirmation.

Different hosts.—Maize and *jowar* (Sorghum) plants, particularly the former, inoculated with Co. 213 mosaic juice developed infection readily with marked mosaic symptoms. Maize plants in the field showed much quicker and better infection than those in the pots, possibly because of the quicker rate of growth of maize plants under field conditions.

The reverse inoculations were made, *i.e.*, mosaic leaf juice of maize and *jowar* plants successfully infected with Co. 213 virus was inoculated into Co. 213 plants. In a recent set of experiments both the maize and *jowar* series have given successful results.

Seasonal variation.—Weather conditions seem to have a strong influence on successful transmission. Experiments to ascertain the most suitable period for successful inoculation tend to show that May and June are about the best months, when percentage infection is high and incubation period short.

"Cyclostage"-isolation attempts.—Exhaustive experiments * have been carried out spread all over the year in attempts to secure fresh isolations of the organism claimed to be associated with mosaic virus, having a visible cyclostage. No "opalescence" or "cyclostage" has been met with in any of the experiments attempted so far. Some of these have been carried on to as many as the twentieth stage of subculture.

Mosaic leaf juices, filtered (L_3) and unfiltered, of cane (different varieties) and maize; of chlorotic cane leaves and leaves affected with "yellowing"; and stem-bits from mosaic affected canes were included in these attempts, following the "standardised" technique and culture media, but without any success.

Varied and continued work to confirm the results recorded by Dr. Desai (*Ind. Jour. Agri. Sci.* V, Pt. 4, 1935) has given completely negative results.

Serological studies

Precipitin test.—Immunized batch of rabbits, *i.e.*, rabbits which have had received eight intravenous injections with L_3 filtrate of healthy and mosaic leaf juice of Co. 213, were made to bleed through the veins. About 5 c.c. of the blood of each was collected. Sera were prepared and tested for precipitin reaction.

Healthy as well as mosaic serum gave positive reaction with healthy and mosaic antigens in the proportions 1 : 1, 1 : 2, 1 : 4, 1 : 8 and 1 : 16. Reaction in 1 : 16 proportion is doubtful. Complete results of the precipitin test are given in the following table.

* Described in detail in the Annual Report, 1935-36 of the scheme for mosaic and other diseases of sugarcane published by the Imperial Council of Agricultural Research.

Undiluted antigen	Mosaic antiserum								Healthy antiserum							
	1:1	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:1	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256
Mosaic	++	++	+	+	?	—	—	—	—	++	++	+	+	—	—	—	—	—
Healthy	++	++	+	+	?	—	—	—	—	++	++	+	+	?	—	—	—	—

++ Heavy ring, + Definite ring, ? Doubtful precipitate — No precipitate.

The above table shows that there is no evidence of virus associated with the filtrate of mosaic juice, the reactions of healthy and mosaic antisera with both healthy and mosaic antigens being exactly similar.

These positive reactions are obviously due to leaf proteins which are present both in healthy as well as mosaic filtrate.

Quantitative estimations carried out showed that the amount of Kjeldahl nitrogen in both healthy and mosaic filtrates is 0·01 per cent.

2. Bacterial and Fungal Diseases

Stinking Rot : (*Bacillus pyocyaneus* var. *saccharum* Desai).—Co. 210, 313, 419 and Lalgira were inoculated both in the spindle and internode with the stinking-rot organisms (mixed culture) isolated from the affected canes from Musheri. The inoculated plants were given moist and humid conditions by spraying them with water twice every day.

Co. 313 and Lalgira showed localised rotting of the inoculated internodes, but the characteristic smell of stinking-rot was absent.

The experiment was repeated with freshly isolated cultures, but without success.

In another set the inoculated plants (in pots) were covered with muslin bags which were thoroughly soaked with water four times a day, thus simulating monsoon conditions. But none of the plants were infected.

Red Rot : (*Colletotrichum falcatum* Went).—Ten plants of each of the varieties Co. 213, Co. 408, Co. 416, Co. 419, Co. 420 and Co. 427 were inoculated with two strains of *C. falcatum*, one isolated from a thick cane variety and the other from a thin one.

Infection took place in all cases, but the spread was very limited with either of the strains. In some cases, however, the infection advanced more with the thick-cane-strain than the other.

In another set of experiments, the cane varieties Co. 210, Co. 213, Co. 313, Co. 419, P. O. J. 2878 and Saretha were inoculated, five plants each, with six strains of *Colletotrichum*—five isolated from affected canes and the sixth from *jowar*. These were : (1) from thick cane, Coimbatore, (2) from Co. 210, Pusa, (3) from *deshi* cane, Patna, (4) from Reora cane, Sepaya, (5) from midrib, Co. 213, Pusa, and (6) from *jowar*, Pusa.

It was found that the *jowar* strain did not infect any of the canes. Strains from Co. 210, Deshi, Reora and " Mid-rib " showed successful infection of all the six varieties, but the spread within the cane was again strictly limited. The Coimbatore strain

infected all the varieties and the progress of infection in the cane though slow was comparatively better than that of the other strains.

Failure of the development of typical red rot symptoms is perhaps due to the plants growing in small pots. The growth of these potted plants was rather abnormal—very short internodes.

Smut : (*Ustilago scitaminea* Syd.).—Ten plants each of the varieties Co. 210, Co. 213, Co. 313, Co. 416, Co. 419, Saretha, P. O. J. 2878, B. 3412 and Lalgira growing in pots were inoculated with cultures of smut isolated from Co. 213. The inoculum consisted of cultures growing on potato-dextrose agar and actively producing secondary sporidia.

Inoculated plants were examined frequently for five months. But no smut infection took place.

Verticillium sp. (? *Trichoderma*).—During the last three cane-seasons at Pusa, at harvest time, some clumps of Co. 210 and Co. 213 were found stunted and drying prematurely in the fields. The drying up had started from the top and progressed downwards ; the pith was found shrunk and peeling off in white flakes. The stem was hollow in many cases ; with brownish discolouration at the nodes. The stem at the ground level was normal ; no change could be detected in the root system. In early stages no fungus could be detected, but in advanced stages of attack a species of *Verticillium*, with minute round spores—dirty green in colour when in mass—was found in some cases.

Inoculation experiments in early stages of growth gave negative results, but later in the season, in November, some successful inoculations were obtained with Co. 213. These results have yet to be confirmed. Further experiments for *Verticillium* infection will be carried out next season.

Seedling Disease.—Results of the work on two seedling diseases of cane caused by *Pythium graminicolum* Subr., and *Helminthosporium halodes* Drechs. have already been published. The disease again appeared this year at the Cane Breeding Station, Coimbatore.

III. SURVEY OF CANE DISEASES

The following places were visited for observations of mosaic and other diseases of cane :—

Bihar : Pusa Farm, Sugarcane Research Station, Musheri (Muzzaffarpur).

Orissa : Puri, Khurda and Cuttack Farms and Banki Area.

Assam : Gauhati and Jorhat Divisions.

United Provinces.: Shahjahanpur.

Punjab : Karnal.

Of special interest during 1935-36 cane-crop surveys is the first record of mosaic on eight cane varieties including P. O. J. 2878 at the Cuttack Farm and downy mildew (*Sclerospora* sp.) on Co. 515 at Shahjahanpur. P. O. J. 2878 is recognised all the world over as a variety immune to mosaic ; as regards downy mildew it is only the second time that this disease has been recorded in India.

Besides the above surveys a special tour was undertaken of the Sugar Factory areas in North Bihar and East U. P. to examine the cane crop for diseases. Various places visited are Motihari, Bara Chakia, Balrampur, Sasa Musa, Marhowrah, Samastipur and Ryam. Cane coming in for crushing in seven factories was also examined.

IV. MISCELLANEOUS

Diseased specimens received were reported upon and suitable control measures were suggested.

Various enquiries of the cane factory managers and private growers were answered, and the required information and advice was given. A few tours were undertaken to study such cane troubles on the spot and suggest remedial measures.

Setts of Uba cane—healthy, mosaic and streak-affected—were supplied to Dr. Storey, Amani Institute, East Africa.

Cultures of *Fusarium moniliforme* Sheld. were supplied to the Sugarcane Specialist, Musheri, Muzaffarpur.

A few Co. 213 canes, obtained from the Imperial Agriculturist, were supplied to the Botany Department, Allahabad University, with complete information about preparation of the setts and their planting, etc.

V. PROGRAMME FOR 1936-37

1. Tonnage experiment to be continued with a thick variety of cane.

2. Varietal test of important provincial varieties to determine their relative susceptibility or resistance to mosaic, red-rot, smut and wilt.

3. Purification and transmission of sugarcane mosaic virus.

4. Study of physical properties of the mosaic virus to be continued.

5. Cultural and inoculation studies of *Colletotrichum falcatum* and *Ustilago* (Smut) for physiological strains.

6. Systematic studies in *Pythium graminicolum*.

7. Studies on *Verticillium* sp., red-stripe, and stinking-rot.

8. Survey of cane crop for disease.
9. Training of students.
10. Routine. General help and advice.

VI. PUBLICATIONS

Rafay, S. A. . . . . Physical Properties of Sugarcane Mosaic Virus. *Ind. J. Agric. Sci.*, Vol. V, Pt. 6, 1935.

Subramaniam, L. S. . . . Some New Seedling Diseases of Sugarcane. *Ind. J. Agric. Sci.*, Vol. VI, Pt. 1, 1936.

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REPORT OF THE IMPERIAL ENTOMOLOGIST

[H. S. Pruthi, M. Sc., Ph. D. (Cantab.)]

I. ADMINISTRATION

Dr. Hem Singh Pruthi, Imperial Entomologist, remained in charge of the Entomological Section throughout the year.

Mr. P. V. Isaac, Second Entomologist, returned from leave and deputation *ex* India on the 9th of February 1936.

The post of Assistant Entomologist vacated by Rai Bahadur C. S. Misra in March 1935 remained vacant throughout the year.

The post of Second Assistant Entomologist was filled by the appointment of Dr. Taskhir Ahmad, B.Sc., Ph.D., with effect from the 14th October 1935.

II. TRAINING

Mr. K. V. Rao, post-graduate student, was under training throughout the year. The training of Mr. E. J. Vevai, post-graduate student, was completed on 31st October 1935, but he joined again in February 1936 to make a further study on the sugarcane root borer. Mr. R. L. Garg was admitted as a post-graduate student on 8th January 1936. Dr. S. M. Das of Lucknow University was under training as a short course student from the middle of November 1935 up to the 4th March 1936.

III. SPECIAL INVESTIGATIONS

During this year again out of the four gazetted officers of this Section the Imperial Entomologist was the only one on duty for some time and was therefore kept constantly busy with advisory, teaching and administrative work of the Section. The Assistants were chiefly engaged on the re-arrangement, registration and cataloguing of the insect collections. Moreover, due to the impending transfer of the Institute to Delhi the grants for apparatus, travelling, etc., had been cut down which seriously interfered with the progress of research work. Only the following special investigations were carried out :—

1. Pests of Sugarcane and their Parasites

Observations were taken regularly every month on the incidence of insect pests, especially *Pyrilla* spp. and borers, on spring plantations in a randomised experimental plot and on the October and ratoon crops at Pusa.

Pyrilla and other sucking insects.—All the three species of *Pyrilla*, *P. aberrans*, *P. pusana* and *P. perpusilla* were found, but *Pyrilla pusana* was most common from July onwards up to the end of the season. As observed in some previous years, the increased humidity of the air at this time of the year seems to help the pest in its rapid multiplication.

The sugarcane white-fly *Aleurolobus barodensis* also multiplied with alarming rapidity during the monsoon months. The infestation by the white-fly was especially severe in the ratoon areas. All the varieties under observation, *e.g.*, Co. 213, Co. 214, Co. 313, Co. 331, Co. 337 and Co. 339, were severely attacked except Co. 299. The variety Co. 331 suffered the most.

The other sucking insects *Assamia moesta* and *Drona carnosa* began to appear in August but they remained in small numbers. *Pseudococcus sacchari* occurred in fairly large numbers but did not do much damage. *Trionymus sacchari* occurred from November onwards in large numbers. On an average 10 per cent of the plants were infested by this pest though in certain counts the infestation was as high as 40 per cent. *Macropes excavatus* occurred in small number during November and December.

Parasite of Pyrilla spp.—The Chalcid parasites *Tetrastichus pyrillæ* and *Ooencyrtus pyrillæ* were first seen in the field about the third week in July. The bionomics of these parasites has been investigated. Parasitization in the Gonhri and Jhilli fields was 42 per cent in the beginning of August but towards the close of the month it went up to 70 per cent. In the experimental plot the parasitization was 22 per cent in August but rapidly increased afterwards as is stated in the table below :—

Month	Percentage of parasitization of exposed eggs	Percentage of parasitization of eggs inside sheathing leaves
September	79·3	..
October	85	39
November	74·4	44·14
December	83·6	61·1

From October onwards the hoppers laid more eggs in the sheathing leaves than on the exposed green and dry leaves. From the foregoing observations it will be noticed that parasitization of the eggs laid on exposed leaves was much higher than those laid in sheathing leaves. The periodical removal of leaf-sheaths therefore should be useful in reducing the incidence of the pests by parasitisation.

The Dryinid parasites of *Pyrilla*, *viz.*, *Dryinus pyrillæ* and *Chloredryinus pallidus* were found first in the field in the beginning of September. The parasitization varied between 1 and 3 per cent during the year under report, the maximum being in September.

The eggs of *Pyrilla* were preyed upon by the neuropterous *Coniopteryx pusana*. The predator appeared in the field in the last week of July. The anatomy, biology and life-history of this enemy of *Pyrilla* has been completed and a paper on the subject will be soon sent for publication.

Borers.—About 4,000 canes were examined every month to note the incidence of borers. The percentage of "dead-hearts" caused by various borers each month are given in the following table. The percentage of dead-hearts in the plots in which they were not removed after the monthly counts is stated in the last column of the table :—

Month	Total No. of dead-hearts	Root-borer	Stem-borers	Top-borer	Accumulated dead-hearts
	%	%	%	%	%
April . . .	5·42	4·88	0·33	0·21	4·28
May . . .	5·49	3·35	1·79	0·34	7·50
June . . .	9·38	2·71	4·36	2·31	..
July . . .	16·23	7·97	1·43	6·83	36·23
August . . .	No observation taken.*				
September . .					
October . . .	16·15	4·41	1·29	10·45	41·00
November . .	12·46	3·83	0·65	7·98	45·25
December . .	9·65	1·95	0·56	7·13	47·50
January . . .	6·24	0·67	0·38	5·19	52·22
February . .	6·08	0·08	0·73	5·27	54·63

* Observations for August and September could not be taken as the cane fields were under floods due to excessive rain. Dead-hearts mentioned against October are therefore the accumulated dead-hearts caused during August, September and October.

It will be noticed that there was a sudden increase in the number of dead-hearts in July.

One thousand plants of Co. 331 from the October plantations and ratoon areas were also examined every month. The observations are summarised below :—

October plantings

Months	Total No. of dead-hearts	Dead-hearts caused by the root-borer	Dead-hearts caused by the stem-borers	Dead-hearts caused by the top-borer
	%	%	%	%
April	10·8			
May	11·0			
June	26·0			
July	22·2	20·2	1·1	0·9
August	28·5	23·2	2·9	2·4
September	21·4	16·6	2·8	2·0
October	22·7	19·0	0·7	3·0
November	31·7	18·7	3·4	9·6
December	26·0	15·0	1·5	9·05
January	36·5	14·8	2·7	19·0
February	41·2	18·7	3·2	19·3

Ratoon crops

Months	Total No. of dead-hearts	Dead-hearts caused by root-borer	Dead-hearts caused by stem-borers	Dead-hearts caused by top-borer
	%	%	%	%
May	9·4			
June	24·4			
July	18·9	13·3	0·7	4·9
August	27·8	23·4	1·1	3·3
September	20·9	17·7	1·2	2·0
October	20·3	16·6	0·7	3·0
November	30·0	14·8	2·3	12·9
December to February		Harvested		

It may be mentioned here that the observations on October and ratoon crops were taken in different parts of the field each month. The percentage of dead-hearts given are therefore those that had accumulated during each month of the observation from the date of planting.

At the time of harvest in March about 2,500 plants (8 replications) of each of the five varieties Co. 210, Co. 213, Co. 299, Co. 313, and Co. 331 were examined for borers and termites and the data are being analysed statistically. The incidence of pests is summarised below :—

Variety of cane	No. of plants examined	Affected by top-borer	Affected by stem-borers	Affected by root-borer	Affected by termites
		%	%	%	%
Co. 210 . . .	2738	51·169	22·50	36·27	7·34
Co. 213 . . .	2774	35·87	33·17	29·89	5·52
Co. 299 . . .	2786	37·19	13·10	26·27	0·68
Co. 313 . . .	2136	40·50	41·25	46·40	3·61
Co. 331 . . .	2017	26·13	18·64	32·15	2·63

The data collected during the March 1935 harvest on the incidence of and damage by pests to Co. 331 have been examined statistically. The following are some of the more important conclusions :—

(*i*) The stem-borer causes the maximum amount of damage both in regard to the quantity and quality of the crop.

(*ii*) The top-borer is next in importance to the stem-borers.

(*iii*) The loss sustained by the attack of termites is variable.

(*iv*) The root-borer in the early stage of the crop is harmful but afterwards it is in no way detrimental to the crop either in regard to tonnage or the quality of the juice.

The results obtained from a similar examination of Co. 214, though not exactly identical with those for Co. 331, were similar to them in essential points. A paper on the subject is ready for the press.

Parasites of borers.—Apantles flavipes, a parasite of the stem-borer *Argyria sticticraspis* reported for the first time last year was seen in the field in the first week of January. This year it was not observed in such large numbers as last year. Both *Argyria sticticraspis* and *Diatraea venosata* were attacked by this parasite. From 15 to 80 *Apantales* grubs develop in each host larva. Three to five per cent of the larvæ were found parasitized during the year under report.

Rhaconotus scirpophagae (Pl. VI, fig. 2), a parasite of the top-borer, was first seen in the field in December, the female parasitising with its long ovipositor the borers lying in the tunnels. The parasitism in the field was rather low (about 2 per cent).

Phanurus sp. (?).—The top-borer eggs were parasitized by this minute chalcid wasp (Plate VI, fig. 3) in the field from March onward. The parasitism varied from 3 to 15 per cent.

2. Insect Vectors of Leaf-curl of Tobacco

The capsid bug *Cyrtopeltus* (*Gallobelicus*) *crassicornis* Dist. (*Engytatus tenuis*) tried last year was given much more extensive trial during the year under report. In the summer of 1935 a pure stock of this bug was bred in the laboratory. In the following December and January fifty transmission experiments for various types of leaf-curl were performed. Both nymphal and adult stages of the bug were employed. The inoculated and control plants were kept under observation up to the middle of April by which date all of them had reached the flowering stage. All experiments gave negative results.

A worker in Rhodesia had shown that if the body fluid of the thoracic regions of specimens of an allied species which had previously fed on diseased plants was injected into healthy tobacco seedlings they developed the leaf-curl disease in three or four weeks. Twenty experiments on similar lines were performed with the bug named above at Pusa during December 1935 but no injected plant developed the disease up to the middle of April.

Sann-hemp is also a victim of virus diseases at Pusa. Its insect fauna has been under our observation since the autumn of 1934. In August 1935 this crop in the plots of the Botanical Section was observed to be suffering from a virulent type of leaf-curl, somewhat resembling that of tobacco. The sucking insect which had been most common on this crop during the previous summer was the common white-fly *Bemisia gossypiperda*. To ascertain whether the virus responsible for the leaf-curl in sann-hemp is the same as that causing the disease in tobacco and whether the white-fly is the vector concerned, twenty transmission experiments were performed in September 1935. Specimens of the white-fly were fed on diseased sann-hemp leaves and then transferred on the leaves of healthy tobacco seedlings under muslin covers. During the third to fifth week after the white-flies had been transferred on tobacco, about 50 per cent of the seedlings showed symptoms of leaf-curl. After the lapse of four or five weeks a few of the affected plants recovered, whereas in the remaining seven the disease developed in a very virulent form. It is noteworthy that all the experimental plants developed the A type of disease. Thus it is evident that sann-hemp is an alternate host of the virus responsible for this type and the white-fly is the transmitter concerned. A paper embodying these interesting observations has been submitted for publication.

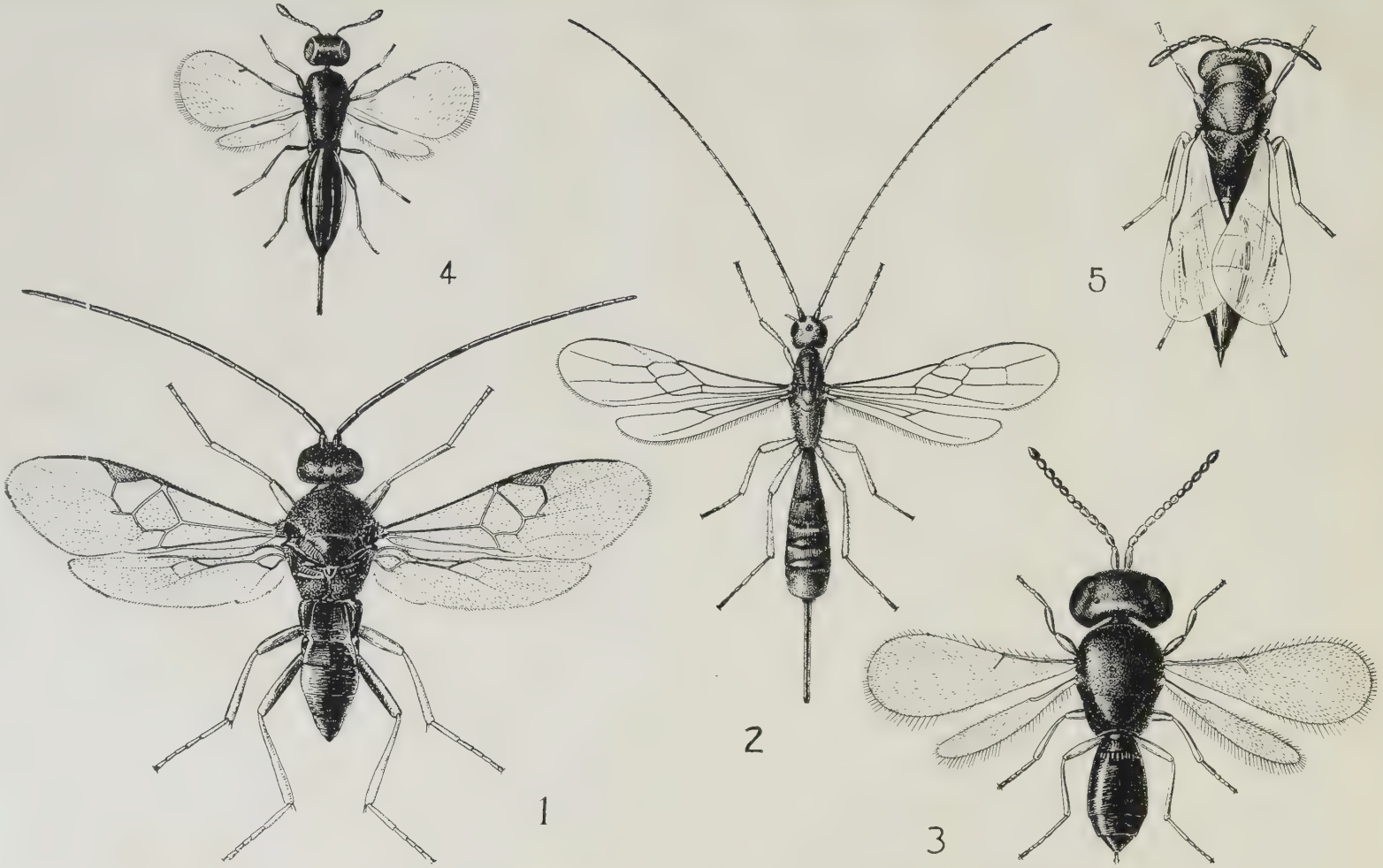

Fig. 1. *Apantales paludicole* Cam. a larval parasite of *Sphenarchis caffer* × 15.
Fig. 2. *Rhaconotus scirpophagae*, a larval parasite of the top borer *Scirpophaga nivella* × 10.
Fig. 3. A chalcid egg parasite of the top borer × 45.
Fig. 4. *Pareuderus torymoides* F. an egg parasite of *Lixus truncatulus*, × 25.
Fig. 5. Proctotrypoid parasite on the pupa of *Lixus truncatulus*, × 12.

PLATE VI

3. Taxonomic studies on Indian Jassidae

The work on this important group of sucking insects which includes vectors of some virus diseases in other countries was continued and two new genera and 25 new species were described. A monograph on this subject was published in the *Memoirs of the Indian Museum*, Calcutta.

4. Linseed Fly

A brief account of this new pest of linseed was given last year. During the year under report it has been further investigated, especially in reference to its incidence on various varieties of linseed. The pest was found infesting the early flowering variety in the second half of January, the attack being 2—4 per cent. In the first three weeks of February it was on the middle-flowering variety, the intensity of attack being only slightly higher than in the case of early variety. The late flowering varieties, both *flax* and *Australian*, suffered the most from this pest. The infestation in the case of the *Australian* rose from 5 per cent in the first week of February to 29 per cent towards the end of this month. In the same period the infestation on the *flax* rose from 13 to 47 per cent.

The pest was not found in the linseed fields after the 5th of March when the seed pods had been formed.

The most interesting and important point which requires elucidation is as to how and on what plants the pest passes the rest of the year. In this connection it is of interest to report that *Cajanus indicus* at Pusa was found being damaged by this or a closely allied species during February. The fly on *Cajanus* has been sent for naming to the same specialist who named the Linseed fly. If the species concerned in both cases is the same, then *C. indicus* is an important alternative host of the pest. The infestation on this host plant in the insectary compound varied from 18 to 53 per cent. Thirty-three types of this crop grown in the plots of the Botanical section were also examined for this pest. Nine of them were found infested, the percentage of attack being 1—7 per cent. The life-history of the fly infesting *Cajanus* was carefully investigated. The average duration of the egg, larval and pupal stages at 20° C. was 2, 6 and 7 days respectively. At 27° C., the duration was 1, 4 and 5 days.

5. Pests of Stored Grains

The study of the influence of various humidities on the biology of the common grain weevil *Calendra oryzae* has yielded interesting results. Weevils were kept in small glass tubes in desiccators, each tube containing only a single pair. A series of humidities was obtained by mixing H_2SO_4 and water in different proportions. Above 95 per cent relative humidity, though the beetles attempted

to copulate no eggs were laid and there was a rich growth of fungi, etc., in the tubes. At 92 per cent humidity a single female laid 630 eggs of which 182 developed into adult weevils. At 75 per cent humidity out of 255 eggs laid 68 developed into adults. Below 50 per cent the beetles did not feed at all on the grain and died within three days without laying eggs. In the absence of a constant temperature chamber the humidity jars were kept in the laboratory, the temperature of which during the duration of experiments was $88\pm7°F$. maximum and $86\pm6°F$ minimum.

The above observations indicate that the pest cannot flourish at relative humidities below 50 per cent.

The duration of the different stages in the life-history of the weevil have also been worked out and a parasite *Aplastomorpha calandrae* How. was bred from its grub and pupæ.

The repellant effect of *neem* cake, a cheap indigenous material, on the weevil seems to be significant. Samples of Pusa wheat 52 containing the repellant and stored for one year in small jars showed the incidence of the pest to be 2·5—9·4 per cent, whereas in the control samples the infestation went up to 50 per cent. These experiments are being repeated on a large scale and under different conditions of storage. Investigations on the influence of the repellant on the viability of the treated grain and on the taste of the flour obtained therefrom will be started after the Institute has shifted to Delhi.

6. The Turpod Agromyza

Although the Turpod Agromyza (*Agromyza obtusa*) was recognised as a serious pest of *Cajanus indicus* over 25 years ago practically no attempt has been made to study its bionomics. The pest was noticed doing serious damage to *tur* pods on the Pusa Estate during March 1936, when the bionomics of the fly and that of parasites bred therefrom (Pl. VII) were investigated. The results are briefly summarized below :—

The eggs are laid inside young pods in which seed-formation has already proceeded to some extent. The maximum number of eggs laid in the laboratory by one female in 24 hours was 28 and in her whole life-time 50. The eggs hatch in $2\frac{1}{2}$—3 days at 27°C. This also represents the incubation period in nature during April. At 22°C. and 18°C. the eggs hatch in about 4 and 9 days respectively.

The young larvæ at the surface of the seed, seldom boring right into it. The larval period is comparatively short, being 9-10 days at 27°C. The full-grown larvæ pupate within the pod. The pupal period was 8-9 and 28—30 days at 27°C. and 18°C. respectively.

The adult flies are short lived If kept without food, they survived 3 to 8 days, depending on the temperature (27°—18°C.).

Fig. 1. *Agromyza obtusa* Mall, a pest of tur pods × 12.
Figs. 2—5. Chalcid parasites (*Euderus* Spp.) bred from the larvae of the above × 20.

PLATE VII.

When fed on honey solution the duration of their life was almost doubled and varied from 7—15 days.

It appears that there are a large number of broods in a year. Tur crop remains in the field from August to April. It has yet to be ascertained how the pest passes the period when the crop is not in the field.

Two larval parasites (*Euderus* spp.) and one hyper-parasite were reared out and studied.

7. Bionomics of *Apantales paludicole* Cam.

This Braconid parasite (Pl. VI, fig. 1) is a serious enemy of the Pterophorid caterpillar *Sphenarchis caffer* which feeds on leaves of *Lagenaria vulgaris*, *Dolichos lab-lab*, *Cucurbita pepe* and on the flowers and pods of *Cajanus indicus*. The pest seems to be kept under check in nature by this parasite. The parasites are seen in the field in Pusa from June onwards. They are very active and beat about the leaves of the plants. The female parasite lays a single egg in the second instar larva of the host. The larval period of the parasite inside the host body is twenty days in winter (November to the first half of February), fifteen days during the latter half of February and March and twelve days during the monsoon months. The pupal period of the parasite is about nine days in winter months and five to six days during the rains. The maximum field parasitism during the year under report was 45·65 per cent in November.

8. Parasites of Fruit Flies

Mr. W. B. Gurney, Entomologist to the Department of Agriculture, New South Wales, visited Pusa in June 1935 and requested the Imperial Entomologist for some suitable parasites of fruit flies for the purpose of introducing them in his country. The most important parasite known from Pusa is *Opius fletcheri* Silv. Before the parasite could be bred in large numbers and exported, detailed information about its life-history under different conditions of temperature, etc., was needed. A special investigation was therefore undertaken with this object in view, the results of which are summarised below :—

The most common host of this parasite at Pusa is the fruit fly *Chaetodacus cucurbitae* Coq. which chiefly infests *gheura* and *jheugni* (*Luffa* spp.) The fly was reared on a large scale at room temperature and in incubators running at constant temperatures of 77°F., 80°F., 82°F., 86°F. and 95° F. respectively. About 2,000 pupæ were under observation. The appearance of *Opious fletcheri* in the field begins in the third week of September. The temperatures between 70° and 77° F. were found to be most favourable for the emergence of

the parasite. Parasitization of the fruit fly larvæ and pupæ in nature was found to be highest in October, when it was 20 per cent ; it subsequently decreased, being 5·2 per cent only in January. A constant temperature of 95°F. was found to be lethal for both flies and parasites. At this constant temperature, some pupal cases were found to have been broken, but no flies completely emerged.

9. The weevil borer of *Amaranthus*

This borer (*Lixus truncatulus*) is a pest of several cultivated and wild varieties of *Amaranthus* spp. in the plains of India. Its life-history, food plants and parasites at Pusa were investigated. The eggs, hitherto unknown, are laid inside the leaf petioles or in tender parts of the stem. The weevil can feed on a large variety of plants but oviposits on a very limited number. A single female lays about 2 or 3 eggs per day during the warm season. In winter oviposition stops altogether. The maximum number of eggs laid by a single female was 174. At constant temperatures of 27°C. and 20°C. their incubation period was about 4 days and 10 days respectively.

The grubs on hatching bore down through the secondary branches into the main stem. When full-grown they make wide chambers for pupation which cause characteristic swellings of the stem. In the case of a severe infestation as many as 155 individuals in different stages of development were discovered from a single plant. The larval period seems to be very variable. On an average it varied from 1½ months in summer to several months during winter. The larvæ hatched during November and December passed the winter in the larval stage. The pupal period was about 9-10 days at 27°C. and 20—24 days at 20°C.

The life of adults is very long, sometimes as many as 148 days. There seem to be at least three broods from March to November. The individuals of last brood overwinter in whatever stage they are, and resume development in spring.

A Cecidomyiid maggot has been recorded for the first time feeding on the eggs of this borer. Two egg and one pupal Chalcid parasites (Pl. VI, figs. 4 and 5) of this weevil have also been discovered.

IV. OBSERVATIONS ON OTHER INSECTS

The various crops growing in different fields of the Pusa Estate were examined throughout the year under report with a view to observing the habits and behaviour of insects doing damage thereto. The immature stages of the pests and their parasites if any were reared in the Insectary. In this way about 120 different kinds of insects were studied during the year.

The following pests occurred on the Pusa Estate on different crops :—

1) *Agrotis ypsilon* Rott. (cut worms) on linseed, gram, potato, cauliflower, cabbage and carrot. The pest was kept in check by hand-picking.

(2) *Diacrisia obliqua* Wlk. on *Phaseolus radiatus*, *Phaseolus mungo* Linn. var. *roxburghii*, *Glycine hispida*, *Vigna catjang*, *Sesamum indicum*, *Pisum sativum*. The pest was kept in check by hand-picking the clusters of young caterpillars.

(3) *Virachola isocrates* Fb. in pomegranate fruits.

(4) *Maruca testulalis* Geyer on *Vigna catjang* and *Phaseolus aconitifolius*.

(5) *Idiocerus* spp. on mango.

(6) *Oxycarenus laetus* Kby. in fruits of *Hibiscus esculentus*.

(7) *Bagrada picta* Fb. on Knol Kohl.

(8) Aphids on *Vigna catjang*, wheat, oats, barley, potato, lentil, chillies, *Melilotus alba*, mustard, turnip, cabbage, cauliflower, gram, tobacco, *Trigonella foenumgraecum* *Cajanus indicus*, and *Sesamum indicum*. They were successfully controlled by spraying with tobacco decoction or nicotine sulphate.

(9) *Aulacophora foveicollis* Kust. on *Cucumis sativus*, *Luffa aegyptiaca*, *Lagenaria vulgaris*.

(10) *Myllocerus 11-pustulatus* on *Cajanus indicus*, *Hibiscus esculentus*, *Glycine hispida*, *Crotalaria juncea*, *Vigna catjang*, and turnip.

(11) Thrips and mites on berseem. They were controlled by spraying with nicotine sulphate or tobacco decoction.

(12) Termites damaging roots of wheat, barley, oats, etc., were kept in check by flooding the field or by irrigating it with water charged with Crude Oil emulsion.

It is of interest to record that some of the pests mentioned above, *e.g.*, *Plusia* spp., *Chloridea obsoleta* Fb. *Prodenia litura* Fb., *Diacrisia obliqua* Wlk., which were breeding on vegetable crops during the winter were found to pass and breed on berseem and lucerne in the spring when the vegetable crops had been harvested.

The following major pests were found in unusually small numbers on the crops noted against them :—

(1) *Prodenia litura* Fb. on peas, cauliflower, cabbage, knol kohl, berseem, and lucerne.

(2) *Plusia orichalcea* Fb. on cauliflower, cabbage, radish, pea, turnip, mustard, carrot, and *Trigonella foenum-grœcum*.

(3) *Plusia nigrisigna* Wlk. on cabbage, and gram.

(4) *Chloridea obsoleta* Fb. on gram, tobacco, and *Cajanus indicus*.

(5) *Laphygma exigua* Hb. on lucerne.

(6) *Hellula undalis* Fb. on cauliflower.

(7) *Crocidolomia binotalis* Zell. on cauliflower.

(8) *Leucinodes orbonalis* Guen. on *Solanum melongena*.

(9) *Pieris brassicae* Linn. on cauliflower.

(10) *Plutella maculipennis* Curt. on cauliflower, cabbage, and knol kohl.

(11) *Antigastra catalaunalis* Dup. on *Sesamum indicum*.

The occurrence of the following insects on the crops mentioned against them is noteworthy :—

(1) *Herse convolvuli* Linn. on *Phaseolus mungo* Linn. var. *roxburghii*.

(2) *Pericallia ricini* Fb. on *Luffa acutangula* and *Luffa aegyptiaca*.

(3) *Cryptopeltis* (*Gallobelicus*) *crassicornis* Dist. on *Sesamum indicum*.

(4) *Dysdercus cingulatus* Fb. on *Crotalaria juucea*.

(5) *Nizara viridula* Linn. on *Glycine hispida*

(6) *Terias hecabe* Linn. on *Trigonella foenum-graecum*.

Parasites were reared from the following pests :—

(1) Tachinid parasites from the larvæ of *Diacrisia obliqua* Wlk., *Plusia orichalcea* Fb., *Chloridea obsoleta* Fb., *Agrotis ypsilon* Rott. and *Crocidolomia binotalis* Zell.

(2) Braconids from *Polyommatus boeticus* Linn., *Hellula undalis* Fb., *Diacrisia obliqua* Wlk. and *Plusia orichalcea* Fb.

(3) Ichneumonids from *Chloridea obsoleta* Fb.

Arrangements are being made for the identification of the above parasites.

V. INSECT SURVEY AND COLLECTIONS

The work on the preserved collections of the Section continued to take considerable amount of time of the whole staff. Specimens of about one thousand species were registered and card catalogued during the year.

Due to the extraordinary financial conditions of the Institute practically no tours were undertaken for the purpose of study or making collection of insects, pests or otherwise. At Pusa an

intensive collection of the insect fauna of tobacco was made. This as well as some of the old unnamed collections were sorted, and named with the help of outside specialists when necessary. Named specimens of about 350 species have been added to the collections. This number also includes some specimens which were received from the following entomologists in India in presentation or exchange :—Entomologists to Governments of Punjab, Madras, and Burma ; Entomologist, Lac Research Institute, Ranchi.

Several consignments of collections were sent for identification to the following authorities whose help is gratefully acknowledged :—

810 specimens of fruit flies to Mr. H. K. Munro, Pretoria, South Africa.

120 specimens of Geometridae to Mr. L. B. Prout, London.

Four big lots of miscellaneous insects to Director, Imperial Institute of Entomology, London.

One lot of Coccidae and Aphidae to Mr. F. Laing, British Museum, London.

50 specimens of Chironomidae to Mr. C. F. Adams, Missouri, U. S. A.

A few small lots of white flies to Mr. Karam Singh Lamba, College of Science, Nagpur.

Over one hundred species of insects received from Provincial Entomologists and various correspondents in different parts of India were identified by the staff of this section.

Authentically named specimens of a large number of species were given in donation or sent on loan to several Entomologists and other workers in India for study.

VI. ADVISORY AND MISCELLANEOUS

Insect Pests, etc.—Fifty-five parcels of insect specimens (comprising about 107 species) received from various parts of India during the year were examined, and identified as far as possible. In the case of pests suitable control measures were suggested.

Information regarding the bionomics and control of termites, pests of sugarcane, stored grains and some other crops was given to twenty-four enquirers.

Advice regarding preparation and use of certain insecticides was given to the Director General of Archæology, Simla, to N. V. Overzeesche Kali Expert Maatschappij, Calcutta, etc.

Several samples of insecticides received for trial were tested and reported on.

Several crops infested with insect pests growing in the plots of the Imperial Economic Botanist and the Imperial Agriculturist, Pusa, were sprayed.

Campaigns against flies and mosquitoes were carried out at the Pusa Estate throughout the year.

As in previous years all entomological work of the Bihar and Orissa Department of Agriculture was attended to.

Bee-keeping.—Information on bee-keeping was given to nineteen different enquirers. Comb foundation sheets and zinc queen excluders were supplied to several applicants.

Issue of certificates, etc.—Forty samples of barley seeds and six samples of sann-hemp fibre received from the Assistant Economic Botanist, Sabour, and intended for despatch to foreign countries, were fumigated and necessary certificates issued. One hundred and forty-four *Phylloxera* certificates were issued for export of orchids, etc.

Coloured plates and lantern slides.—Fifty-three coloured plates of different pests were supplied to different correspondents. Five coloured lantern slides were prepared for and supplied on payment to the Extra Assistant Director of Agriculture, N.-W. F. Province, Peshawar.

Supply of specimens of insect pests for demonstration.—Seventeen species of fruit pests to the Horticulturist, Sabour, several specimens of major pests of important crops to Dewas State, six show cases of sugarcane pests to the Sugarcane Specialist, Mushari, and four show cases of important crop pests to the Director of Agriculture, Bihar and Orissa, were supplied.

Miscellaneous.—Miss R. Shah, Officiating Horticulturist, Department of Agriculture, Bihar and Orissa, Sabour, visited the Section in November 1935 and specimens of important pests of fruit trees were shown to her and their control measures explained.

Mr. M. S. Mani of the Zoological Survey of India, Calcutta, came to Pusa and consulted our collection of Chalcid Hymenoptera.

VII. PUBLICATIONS

The following papers were submitted for publication during the year :—

1. Codling Moth in India. By Hem Singh Pruthi.
   Agric. and Live-Stock in India, Vol. V, pp. 522-523, 1935.
2. Entomological Investigations on the Leaf-curl disease of Tobacco. I. Transmission experiments with some suspected insect vectors. II. An Alternative Host of the Virus and the Insect transmitter. By H. S. Pruthi and C. K. Samuel.

3. Studies on Indian Jassidae (Homoptera). Pt. III. Descriptions of some New Genera and Species, with first Records of some known species from India. By H. S. Pruthi. *Memoirs of the Indian Museum*, XI, 1936.
4. Fish Mortality. By H. S. Pruthi, *Science*, LXXXIII, 1936.
5. A simple, cheap and effective Fly trap. By Mohammad Shaffi. *Agric. and Live-Stock in India*, Vol VI. 1936.
6. Importance of the study of Insect Ecology in Applied Entomology. By Taskhir Ahmed.
7. A study of the loss caused by Borers and Termites to sugarcane at Pusa. By H. S. Pruthi and E. S. Narayanan.
8. List of Publications on Indian Entomology for the year 1935.

VIII. PROGRAMME FOR 1936-37

After the Institute has been shifted to Delhi the first item of work on the programme will be a careful study of the insect fauna and pests of the area. Pests of cotton will be paid special attention. Studies on pests of stored grains, fruit flies and their parasites will be continued. Investigations on the pests of fruit in North India will be undertaken.

REPORT OF THE SECOND ENTOMOLOGIST (DIPTERIST)

IN CHARGE OF

SUGARCANE PESTS RESEARCH SCHEME

(P. V. Isaac, B.A., M.Sc.)

At the beginning of the year I was in Europe on leave. From the 23rd October 1935 I was on deputation to visit the United States of America, Canada, Porto Rico and Hawaii to study the latest methods used in the biological control of injurious insects and the most modern ways practised for the protection of sugarcane from insect pests.

I reached New York on the 30th October and went to Washington where I had interviews with Mr. S. A. Rohwer, Assistant Chief of the United States Bureau of Entomology and Plant Quarantine, and Mr. C. P. Clausen, Senior Entomologist in charge of Foreign Parasite Introductions, Mr. P. N. Annand, Principal Entomologist in charge of cereal and forage insect investigations, Mr. W. R. Walton and several other experts. I also called on Mr. L. O. Howard, former chief of the Bureau of Entomology. I also visited the United States National Museum and the Cane Introduction green-house. I saw the work at Moorestown where parasites are reared in large numbers for the control of pests.

Next I went to Belleville (Ontario), Canada, where the most modern laboratory in the world for parasite rearing for biological control was nearing completion. Canada undertook this development as a result of definite success achieved in controlling pests by means of introduced parasites and also by transferring indigenous parasites from one tract to another. I visited Porto Rico next and saw the work on the control of sugarcane pests and other insects at Mayaguez and Rio Piedras, San Juan, Caguas and Hormigueras.

Louisiana State was next visited and I saw the work on sugarcane insects at Houma and Baton Rouge where I had a long interview with Dr. W. E. Hinds, Entomologist of the State University. Dr. Hinds' name is well known for the large-scale experiments in the use of *Trichogramma minutum* Riley for the control of the sugarcane borer *Diatraea saccharalis*. Going to California next I met Dr. A. W. Morrill at Glendale, Los Angeles, and saw his laboratory for the mass production of *Trichogramma minutum*. At Riverside (California) I saw the modern parasite rearing laboratory at the Citrus Experiment Station.

Leaving California from Los Angeles by steamer I reached Honolulu (Hawaii). Here I visited the laboratories and experimental fields of the Hawaiian Sugar Planters' Association and met Dr. H. P. Agee, Dr. H. L. Lyon, and the Entomologists Dr. C. E. Pemberton and Dr. O. H. Swezey. I left Hawaii on the 31st December 1935 for India and on the way made a short stop in Japan where I visited both the Chief Agricultural and Sericultural Experimental Stations.

I landed in Bombay on the termination of my deputation on the 7th February 1936 and arrived in New Delhi two days later and immediately reported to duty.

After attending the meeting of the Sub-Committee of Entomologists of the Imperial Council of Agricultural Research in New Delhi on 15th February 1936 and discussing with the Director about my future work on sugarcane insects, I visited Muzaffarnagar for two days and saw the experimental study there of different varieties of sugarcane under observation for varietal resistance to insect pests and the influence of various soil treatments on the incidence of pests.

After Muzaffarnagar I visited the Imperial Sugarcane Station at Coimbatore. The great opportunity here is for studying morphological characters in sugarcanes with reference to their influence on insects in their choice of canes for attack. Varieties which show outstanding differences in their attraction to pests were marked and studied, and attempts will be made to collect definite data regarding insect incidence on them and also for the study of characters that seem to influence the varied incidences. Broad bending leaves giving shade seem to encourage *Pyrilla*. Hairyness of leaf affects the numbers in which *Aleurolobus* appears and hardness of rind affects borer populations.

A visit to the Nellikuppam-Palur area enabled me to go through the history of a recent *Pyrilla* plague there. There was a sudden increase of *Pyrilla* in this area in 1933 and the pest did great damage in 1934 and 1935. An examination of meteorological reports showed that there had been an unusual and heavy rainfall in March 1933, and it was this that helped the pest by killing parasites and increasing the amount of soil moisture, thereby favouring the feeding requirements of the bug.

Anakapalle was also visited. The Aleurodid bug is a bad pest in this area and appears to have no parasite controlling it. Parasites of this pest are known from Pusa, and Anakapalle affords a good opportunity for the field-trial of an introduced parasite for the *Aleurodes*.

At Pusa there is this year an unusual incidence of the sugarcane Hispa which is a sporadic pest and there is an opportunity to study the natural enemies of this beetle pest.

Consolidated reports of all past work on sugarcane insects in the Provinces, Pusa and the States were expected in May. Only a few came in. These were reports from the Central Provinces and Bengal to say that no research work of any magnitude had been done on sugarcane in either Province.

From 1st April, 1936, I was placed in full independent charge of the Scheme for Research into the Insect Pests of Sugarcane. No appointment of staff was made during the year. It is expected that all necessary appointments will be made when the Imperial Institute of Agricultural Research starts work in New Delhi.

Programme of work for 1936-37

(1) Collection and identification of all sugarcane insects and their natural enemies.

(2) Observation of the major pests on different varieties of sugarcane at Delhi-Karnal, Pusa and Coimbatore.

(3) Experiments in biological control of the major pests by means of indigenous and imported natural enemies.

(4) Study of the habits of sugarcane insects and their natural enemies for purposes of control experiments.

(5) Collating reports on sugarcane pests from Provincial and State Entomologists in India.

GIPD—M 372DrIIofAR—21-1-37—500.